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A GUIDE

TO THE

QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE URINE,

DESIGNED ESPECIALLY FOR

THE USE OF MEDICAL MEN.

BY

DR. C.arl NEUBAUER AND DR. J.ulius VOGEL.1814-80

FOURTH EDITION, CONSIDERABLY ALTERED AND ENLARGED.

(*With 4 Plates and 26 Woodcuts.*)

TRANSLATED BY

WILLIAM O.rlando MARKHAM, F.R.P.L.,

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rs ago, and some sheets of it had already passed through the
ss, when a fourth edition of it was announced as forthcoming in
many. As this, the fourth edition, had undergone complete revi-
n, and contained many important additions, it was thought
isable to await its appearance before publishing the translation.
ough the kindness of Dr. Neubauer and Dr. Vogel in furnishing
Society with proofs of the new edition as it was passing through
press in Germany, the Translator has been enabled to produce
English version very soon after its appearance in Germany.

LONDON, *July*, 1863.

26144

PREFACE TO THE FOURTH EDITION.

THE first edition of this work on the Analysis of the Urine was presented to the Medical Profession in 1854, subsequent to a course of Lectures on the subject delivered by me to Medical Men and Pharmaceutists at Wiesbaden. The chief object which I had in view in its production was, that it should be of service to the physician engaged in practice. The favourable reception which it met with convinced me that it had not altogether failed in this respect; and induced me when, in 1856, the book was a second time called for, once again to work out thoroughly the whole subject-matter of it. Besides this, in order to meet a desideratum, Prof. J. Vogel undertook what now forms the Second Division of the work, the Semiology of the Human Urine. In this new form the book appeared in 1856; and again a third time in 1858. Another edition, the fourth, has now been called for.

In this fourth edition I have still endeavoured above all to keep the practical in view, so as to render the book a safe guide for the Physician and the Pharmaceutist in their investigations into the state of the urine. The medical student it is hoped will also find in it a clear description of the chemical characters of the normal and abnormal constituents of the urine. The first part treats of the chemical character of the different normal and abnormal constituents of the urine, and contains many new methods for their preparation and tests; several of the processes formerly given have been worked out anew, and the whole subject brought up to a level with the science of the day. Moreover, the large number of investigations into the urine, which have been made in the laboratory here by

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I have to thank the Publishers of Funke's Atlas of Physiological Chemistry, for the permission given me to use their plates.

C. NEUBAUER.

WIESBADEN, *November*, 1862.

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BY DR. C. NEUBAUER.

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EXPLANATION OF PLATES.

PLATES I. TO III., FIGS. 1 TO 4,
ARE TAKEN FROM DR. O. FUNKE'S PHYSIOLOGICAL ATLAS.

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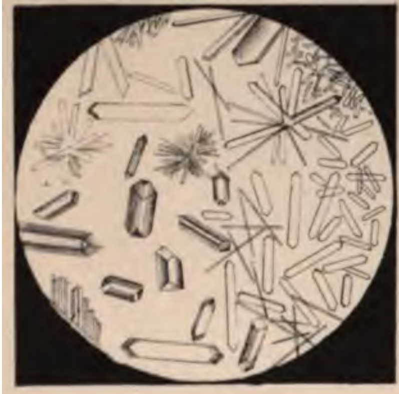
Fig 1.



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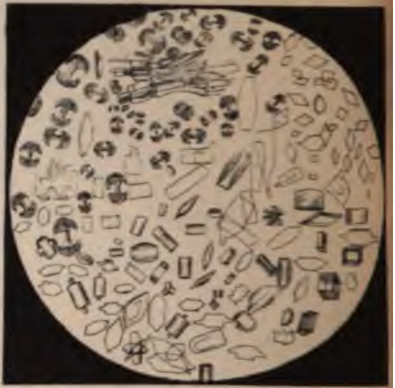

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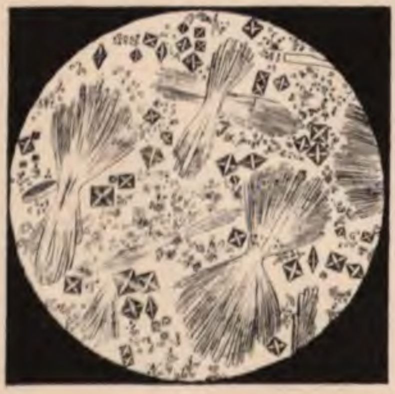

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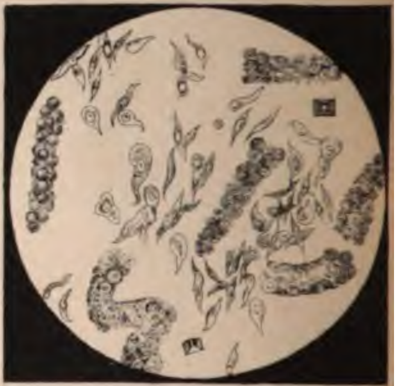

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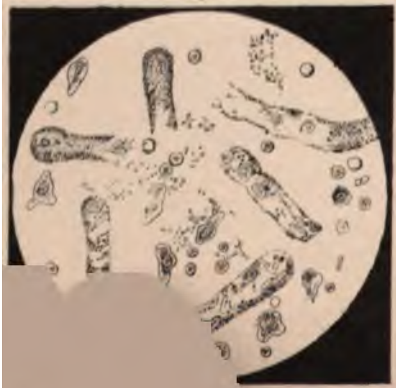

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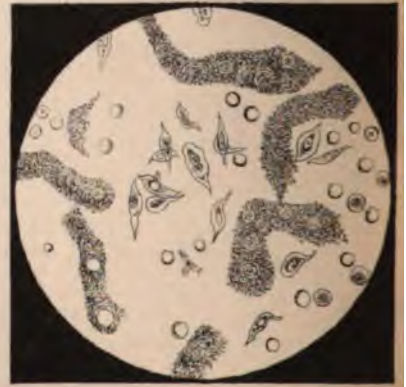

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PLATE I.

Fig. 1. *Hippuric acid, obtained from healthy human urine, and re-crystallised out of water.*

Besides the ordinary prisms, crystals perfectly similar to those of the triple-phosphate are often formed, especially when the hippuric acid is slowly deposited. Crystals of this sort may be seen in the lower third of the figure to the left.

Fig. 2. *Uric acid in different forms, partly prepared from solution and crystallisation of chemically-pure uric acid, partly from urinary sediments by the action of acids on urates, and partly from spontaneous deposition out of urine.*

The various forms of uric acid, from the most ordinary kind, viz., the simple rhombic tables with obtuse rounded angles, up to the more rare modifications, may be readily recognised in the figure. The dumb-bell shaped forms, shown in the upper part of the figure to the left, which also sometimes appear spontaneously, are well represented. Funke always obtained them by dissolving chemically-pure uric acid in concentrated caustic potash, and then decomposing the solution under the microscope by means of concentrated hydrochloric acid.

Fig. 3. *Urinary sediment, consisting of uric acid, urate of soda, and oxalate of lime from the urine of a person convalescent from typhus.*

A formation of uric acid crystals, not unfrequently met with in sediments, consists of large, dense bundles, two of which are joined together at their base; these bundles are composed of an infinite number of long, fine, whetstone-shaped crystals, which are for the most part colourless. The brilliant, letter-cover shaped crystals are oxalate of lime. The little roundish and angular dark-coloured granules, lying singly, or massed together in irregular groups, consist of urate of soda, which always appears in the urine in this molecular form. (Compare Plate II., Figs. 1 and 2.)

Fig. 4. *Urinary sediment, consisting of epithelial cylinders, and numerous epithelial cells, taken after death from the bladder of a patient who had died of typhus.*

The cylindrical tubes consist of the epithelial lining of the renal tubuli, whose round nucleated cells are distinctly visible, through a fine granular mass of molecules. The club-, caudate-, and spindle-shaped nucleated epithelial cells are derived from the ureters, the pelves, and calices of the kidneys.

Fig. 5. *Urinary sediment, consisting of cylindrical hyaline bodies, epithelial cells of the bladder, and mucus-corpuscles, from a patient suffering under acute miliary tuberculosis.*

These urinary cylinders are more rarely met with than the last-mentioned kind; they are hyaline and homogeneous, and require care to distinguish them from the surrounding fluid. In this case they here and there appear unusually distinct, in consequence of being covered with small granules of urate of soda. Their extremities are somewhat globular and distended. Moreover, there are seen roundish, long, or polygonal, and for the most part distinctly granular pavement-epithelium of the bladder, and very granular mucus-corpuscles.

Fig. 6. *Urinary sediment, consisting of cylinders of fibrine, blood-, and pus-corpuscles, and epithelial cells from the albuminous urine of a typhus-patient, in whom post-mortem examination showed well-marked inflammatory infiltration of the cortical substance of the kidneys.*

The granular cylindrical bodies formed of a well-marked molecular mass, are fibrinous coagula (croupous exudation) from the renal tubuli, whose shape they in fact represent. Some of them contain blood- and pus-corpuscles, a considerable number of which are also seen free, the blood-corpuscles being most of them swollen, and some few of them with the central depression still distinctly visible. The bipolar epithelial cells have been already described under Fig. 4.

PLATE II.

Fig. 1. *Urinary sediment, consisting of urate of soda from the morning urine of a tuberculous patient.*

The ordinary whitish, yellowish, or tile-red deposit, which is separated from concentrated acid urine as it cools in the air (especially in febrile states of the body), almost invariably consists of urate of soda, in the form of molecules and granules. When rapidly separated, these granules are very fine, and generally deposited together in groups, as here shown. When the urine has stood some little time (Fig. 4), a few fermentation-fungi may also be seen, and occasionally epithelial cells of the bladder, which are mostly very granular and round (see the right lower border).

Fig. 2. *Urinary sediment, consisting of urate of soda, phosphates, and mucus-coagulum, from urine which has stood three days.*

Here the urate of soda is seen separated in the form of much larger and darker granules, and in larger masses than in the former case. The regularly granular and membranous-like forms seen in the centre of the figure, are fragments of the pellicle of amorphous phosphatic earths, which often forms on the surface of urine undergoing decomposition in the air. The smaller and broader twisted bands, which consist of extremely fine points and granules, ranged together in rows, are mucus-coagula, which are not unfrequently met with in acid urine; and may be easily mistaken for the urinary casts above spoken of. Here also we find fermentation-fungi in rows and masses (as at the under border), and a few very granular mucus-corpuscles.

Fig. 3. *Urinary sediment, consisting of triple-phosphates, and of numerous mucus-corpuscles, found in the recently passed turbid alkaline urine of a patient suffering under vesical catarrh.*

The crystals of ammonio-phosphate of magnesia are of different forms; but may be readily recognised, without crystallographic or chemical analysis. The mucus-corpuscles are rather small, very contracted, and granular, and for the most part united by their borders into large groups.

Fig. 4. *Urinary sediment, consisting of urate of soda, uric acid, and fermentation-fungi, from urine which has undergone the acid-fermentation.*

Normal urine, and almost every kind of acid, abnormal urine, after long standing, undergo the acid-fermentation. Small nucleated fermentation-fungi form as the fermentation advances, and increase by gemmation, and in this way form simple and branched rows, as shown in the figure. At the same time, the yellow-coloured uric acid crystals are gradually separated from the ordinary form of urate of soda, and changed into the simple forms here shown. Moreover, small octohedra of oxalate of lime (as seen at the upper right border) often appear.

Fig. 5. *Urinary sediment, consisting of crystals of triple-phosphate and urate of ammonia, from urine which has passed into the stage of alkaline-fermentation, taken from a patient suffering from paraplegia consequent on disease of the spinal cord.*

The crystals of triple-phosphate shown are those most commonly met with in decomposed urine. The urate of ammonia is first of all separated in the form of fine molecules, out of which are gradually formed little globular bodies, which are dark, strongly refractive of light, and become at last studded with fine needle-points of different lengths, like the thorn-apple.

Fig. 6. *Nitrate of urea, separated by means of nitric acid from highly-concentrated human urine.*

Pl. II

Fig. 1

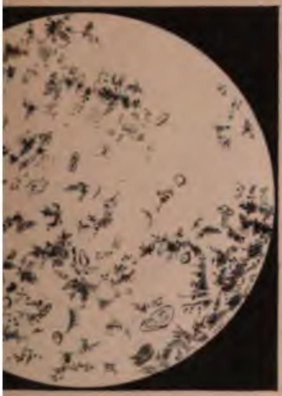

Fig. 2

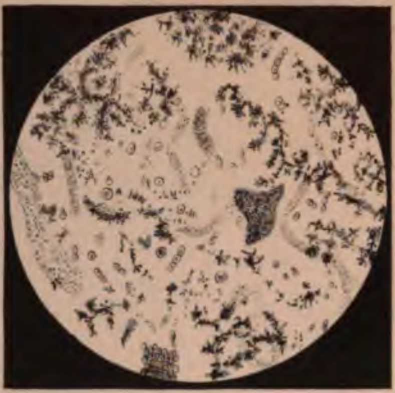

Fig. 3.

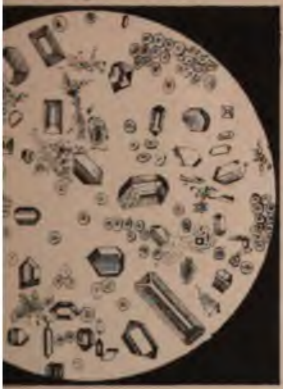

Fig. 4

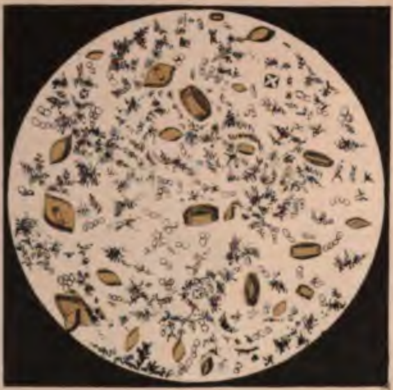

Fig. 5

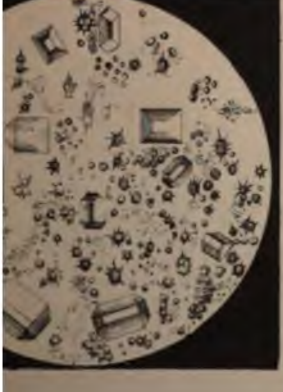

Fig. 6

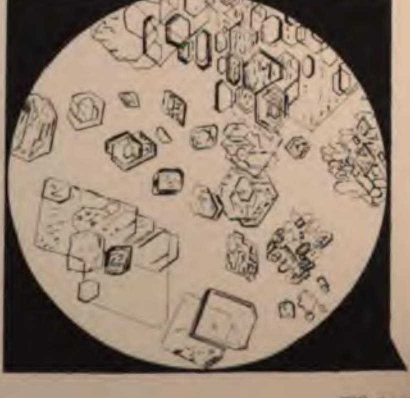

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Fig. 1.

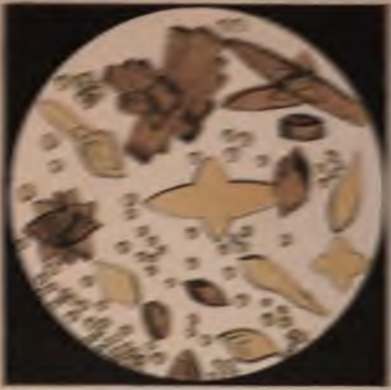
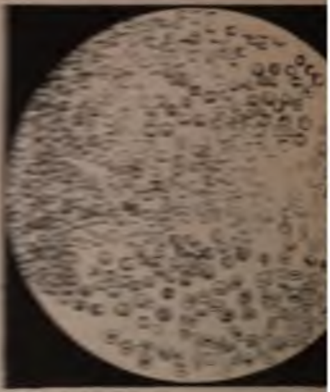


Fig. 2.



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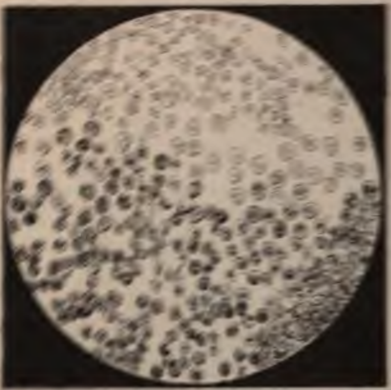

Fig. 4.

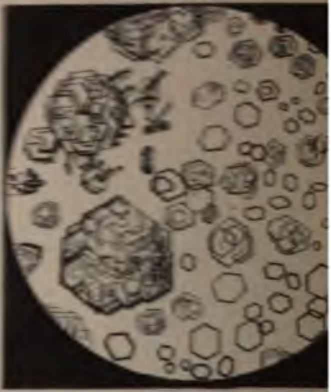

Fig. 5.

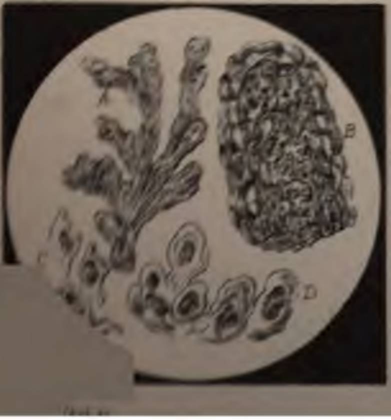

Fig. 6.

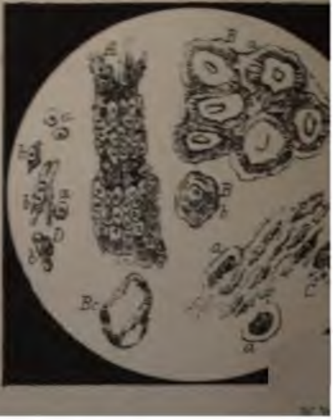

PLATE III.

Fig. 1. *Urinary sediment, consisting of crystals of uric acid from the urine of a girl suffering from acute rheumatism during the menstrual period.*

Numerous well-marked yellow, vesicle-like, distended blood-corpuscles of different sizes are seen, as well as brownish-yellow rhombic tables, and other forms of uric acid, which are for the most part disposed in groups and glands, representing the ordinary forms of urinary sediment, which so often appear as a yellow-shining granular sand.

Fig. 2. *Human blood-corpuscles, treated with water.*

The gradual changes which the blood-corpuscles pass through, under the action of water, are seen in the figure (proceeding from the left border of it to the right). The cells in the first place swell out, take a somewhat lens-like form, and at length become spherical, the point of central depression being gradually elevated, and at last bulging out. At the same time, the diameter of the disc is necessarily diminished. They consequently appear smaller, the central shade becomes indistinct and at length disappears, whilst at the borders a circular shadow appears; in a few cells lying at the border the lens-shaped form is distinctly seen. By further action of the water, the cells become paler and more indistinct, so as to be with difficulty distinguished from the surrounding fluid, the contents of the cells—in consequence of the imbibition of water—having the same light-refracting power as the water around them. They appear as extremely fine hyaline vesicles, and at last become wholly invisible.

By adding a concentrated solution of neutral salt to the water, the corpuscles again appear as angular, misshapen, indented forms (as seen to the right of the figure).

Fig. 3. *Pus-corpuscles.*

In the lower half of the figure, normal *pus-corpuscles* are seen in the form of round, pale, indistinctly-granular vesicles of different sizes; some of them having a single round, excentrically-placed nucleus, and some again a compound nucleus. Some of the cytoid corpuscles, as the figure shows, have a well-defined contour, whilst in others the contour appears indistinctly marked. In the upper half of the figure are seen the results of the action of acetic acid on pus-corpuscles. The corpuscles swell out, their surface becomes smooth, and so hyaline that their contour is hardly distinguishable; the nuclei consequently appear in various numbers and forms, sometimes single, round, oval, of a biscuit- or horse-shoe shape, sometimes two, three, and four in number, and of different forms and differently grouped, resulting from the division of the single nucleus.

Fig. 4. *Cystine taken from a vesical calculus, and re-crystallised out of ammonia.*

Figs. 5 and 6 *represent the most important and frequently met with organic forms which are found in urinary sediment in cases of cancer of the bladder.*

For the special explanation of the single figures and their signification, see Section CVI.

PLATE IV.

(Table of Colours after Vogel.)

Fig. 1. Pale-yellow.
„ 2. Bright-yellow.
„ 3. Yellow.
„ 4. Reddish-yellow.
„ 5. Yellowish-red.
Fig. 6. Red.
„ 7. Brownish-red.
„ 8. Reddish-brown.
„ 9. Brownish-black.

Pl VI

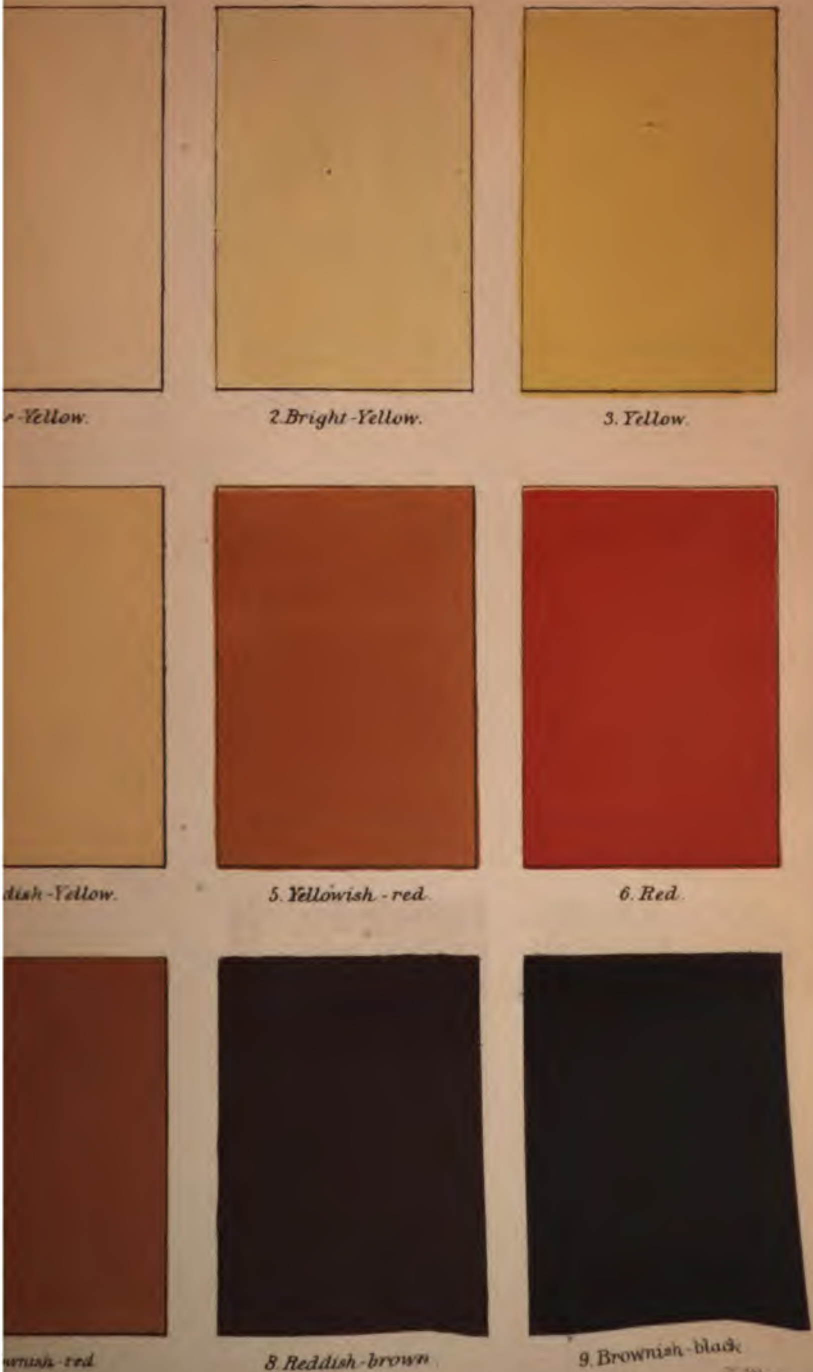

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Table of Colours of the Urine.

(VOGEL)

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INTRODUCTION.

THE rapid development which Chemistry has undergone during the last decennial period has caused its influence to be generally felt, both in the arts and sciences. Manufacturers and agriculturists have at length become convinced of its importance, and, consequently, study it with zeal. Chemistry has also been of great service to the healing art, and, doubtless, will render it still further services. To this science, in fact, must be attributed, in great part, the advances made by physiology and pathology in modern times.

The functions of respiration and nutrition have become more comprehensible since chemistry, with its balance and weights, has determined the character of the metamorphic processes. Physiologists and physicians have long understood the importance of a careful study of these processes; and have referred to them when giving an account of the greater or less rapidity of the changes going on in the body.

Zoo-chemical analysis has also necessarily advanced under the active zeal of so many observers, and has undergone a rapid development. It has taught us that the urine is a collection of the products of the decomposition of the animal structures, and that from the study of the urine we may hope to obtain positive conclusions concerning the nature of the organic processes going on in the diseased, as well as in the healthy, body.

The urine has, indeed, been at all times an especial object of study with zoo-chemical analysits. Several substances have been discovered, and many phenomena observed in it, from which we are enabled to draw conclusions concerning the functions of the animal economy.

Heretofore, and up to a late date, the analysis of the urine has been a long and difficult process; indeed, almost impracticable in the hands of the physician. But it is not so now. The physician, armed with the simplest and newest methods of analysis, is now able in a short time, and at the bedside of the patient, to test the urine, and thereby to discover in it the presence of abnormal constituents, or to determine the quantity of any of its normal constituents. This method of analysis of the urine, combined with a scientific application of the microscope, enables us to arrive at positive conclusions concerning changes going on in the body.

It is intended, in the following pages, to give, in the first place, a sketch of the urine in its healthy state; and also to point out the peculiar changes which it undergoes, as consequences of its acid and alkaline fermentations. In the first portion of the work the chemical characters of all the normal, as well as abnormal, organic and inorganic, constituents of the urine will be detailed. Their appearance, also, under the microscope, will be especially considered.

In the second portion of the work, the different methods to be used in determining the quantity of the constituents of the urine will be described, as well as the necessary precautions, manipulations, and modifications required in carrying them out. The third part will contain a practical guide to the qualitative and quantitative analyses of the urine and its sediments,—such as the chemistry of the present day affords.

A clear idea of the contents of the work may be obtained from the following summary:—

First Part:

1. Physical and Chemical Characters of the Healthy Urine.
2. Normal Constituents.
    a. Organic.
    b. Inorganic.
3. Abnormal Constituents.
4. Sediments.
5. Accidental Constituents.

Second Part:

Determination of the Weight of the Organic and Inorganic Constituents of the Urine.

Third Part:

1. Practical Guide to its Qualitative Analysis.
2. Characters of the Sediments under the Microscope.
3. Practical Guide to the Quantitative Analysis of the Urine.
4. Practical Guide to the Approximative Valuation of the Quantity of its Constituents.

FIRST PART.

SECTION I.

The physical and chemical characters of healthy urine.

THE urine, physiologically considered, is a peculiar organic secretion, which is separated from the body by special organs, the kidneys. It contains, in solution, various nitrogenous and saline compounds, the products of the transformations of the tissues, which are no longer serviceable for the purposes of nutrition.

The constituents of the healthy urine are, in the main, to be regarded as products of the metamorphoses of the tissues of the body. The most important of them are the following organic nitrogenous compounds:—Urea, uric acid, hippuric acid, xanthine, and creatinine; and colouring and extractive matters.

Urea is the most important constituent of human urine. It is the chief product of the retrograde metamorphoses of the nitrogenous tissues, and undoubtedly results from their oxidation, although we are quite ignorant of the way, in which the oxidation is effected. Notwithstanding the many attempts which have been made, urea has unfortunately not yet been artificially produced by the action of powerful oxidising agents on proteine-compounds.*

In addition to the compounds above-named, the mineral constituents of the blood, rendered useless for the purposes of life,—and other matters, which, having been introduced into the body, either interfere with, or do not assist in its nutrition,—are also discharged with the urine, either unchanged or decomposed. The kidneys, moreover, through the urinary secretion, regulate the amount of water in the blood, and maintain it at a pretty equable quantity.

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* The statement made by Béchamp, that urea may be produced by the action of permanganate of potash on proteine has not been confirmed by Städeler and myself

ON THE CHARACTERS OF HEALTHY URINE

[illegible] and its composition [illegible] The difference between the [illegible] herbivorous animals shows [illegible] composition. The [illegible] differ essentially from that [illegible] bright-yellow colour, [illegible] reaction. The [illegible] of uric acid is some- [illegible] entirely [illegible] and then [illegible] In the case of animals [illegible] after having been shut up [illegible] differs considerably from that [illegible] recognised by its constant [illegible] as well as by the presence [illegible] carbonates of the alkalis and [illegible] quantity of urea, and, [illegible] acid is not found [illegible] in very small quantities. [illegible] carbonate of lime, are always present in the sediment of this urine.

The influence of food on the composition of the urine is also clearly shown when an herbivorous animal is fed on animal diet, or when it has been kept for a long time fasting, and its life sustained solely at the cost of its own tissues. Under such circumstances, the urine very soon loses its natural alkaline character, and becomes acid; urea appears in it in considerable quantity; carbonate of lime is no longer found in the sediment, and an appreciable quantity of uric acid is generated in it. It thus assumes completely the characters of the urine of a carnivorous animal—a fact of which anyone may readily convince himself by experiments on rabbits. The reverse of this happens when a carnivorous animal is fed on vegetable food.

The urine of birds, and of amphibious animals, &c., differs altogether from that of the mammalia, showing that the organisation of the animal exercises a distinct influence over the composition of its urine.

Healthy human urine, as a rule, resembles that of carnivorous animals. When recent, it is clear, and of a bright amber colour, has a distinct acid reaction, a saltish bitter taste, and a peculiar aromatic odour. Städeler has, after much labour, thrown some light upon the nature of the odorous matter of the urine; but his experiments refer to the urine of cows rather than to that of man. He succeeded, by the distillation of a large quantity of cows' urine, in recognising as the source of the odour a series of peculiar volatile acids, viz., phenylic acid, and taurylic, damaluric, and damolic acids. Human urine contains much smaller quantities of these acids; and it was only when a considerable amount of it was operated upon, that the presence of phenylic acid could be distinctly recognised by its characteristic reactions.

The specific gravity of healthy human urine varies between 1·005 and 1·030—according to the age, the sex, the constitution of the body, and the food.

The cause of the constantly acid reaction of healthy human urine has been much disputed. Liebig thinks, that it depends chiefly upon the presence of an acid phosphate. According to the researches of Lehmann, however, there can be no doubt, that in many cases, free hippuric and lactic acids exist in the urine, and consequently assist in giving it its acid reaction. The urine may be preserved for a long time, protected from the contact of air in a closed glass vessel, without suffering any particular decomposition. But when exposed to the air, peculiar and important changes take place in it, and these we shall next more particularly consider.

When fresh urine is left to itself in an open vessel, slight clouds of mucus, which gradually sink to the bottom of the vessel, usually soon begin to form in it. In this mucus we find, under the microscope, some pavement epithelium of the bladder and urethra, as well as mucus-corpuscles, united together by fine granular shreds of mucus. A deposit of urate of soda, also, may be often readily recognised in it.

When the urine has been left at rest a still longer period, and especially under the influence of a moderate degree of heat, its acid reaction becomes stronger; and distinct crystals of impure uric acid are at the same time deposited on the sides and bottom of the glass. This increase of its acidity usually goes on for some days, and may even continue for two or three weeks. The acidity, however, at last begins suddenly to diminish, and gradually disappears. The urine now changes its colour, and becomes lighter; a whitish, iridescent pellicle forms on its surface; and the presence of an unpleasant ammoniacal odour indicates that it has become alkaline. The crystals of uric acid disappear, and whitish granules, and colourless, highly-refractive prismatic crystals are formed.

These two phenomena may be distinguished by the names of acid and alkaline fermentations of the urine.

Scherer has arrived at some interesting conclusions in reference to the decompositions which attend these fermentations. The most important are the following:—He considers that the vesical mucus of the urine is the original promoter of the acid fermentation. He, in fact, regards it as a ferment, whose presence occasions a decomposition of the extractive colouring-matter of the urine, this matter being thereby converted into lactic and acetic acids. In this way the increase of free acid in the urine is produced. A considerable quantity of fungi, at the same time, may be seen in the urine, under the microscope. These may be regarded both as the proof, and probably, also, as the promoter of the fermentation; they closely resemble the cellules of the yeast-plant in their external characters, but are somewhat smaller; their mode of growth is similar, and so also their linear arrangement. In consequence of the formation of the above-mentioned powerful acids, the bases of the readily decomposed urates are separated from the uric acid, which is then thrown down in the shape of well-formed crystals. Crystals of oxalate of lime may also almost always be detected in this uric-acid sediment. Of their manner of origin I shall speak more fully under the head of the sediments. (*Plate II. Fig.* 4.)

The free acid of the urine, after a longer or a shorter period, at length begins to diminish, and then commences the second stage of the urine fermentation, the alkaline. The urea is now decomposed, and converted into carbonate of ammonia;* the crystals of uric acid, which had been gradually separated, disappear, and whitish granules of urate of ammonia, as well as prismatic crystals of urate of soda, which often stud the dissolving crystals of uric acid, in a radiated form, take their place. (*Plate II. Fig.* 5.) As the decomposition proceeds, and as the alkaline reaction commences, a

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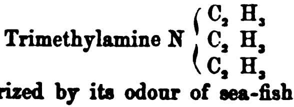
* Beside the carbonate of ammonia, small quantities of other volatile bases,—so-called substitution ammonias,—appear to be formed. Of these, Dessaignes has already noticed one called



$$\text{Trimethylamine } N \left\{ \begin{array}{l} C_2\,H_3 \\ C_2\,H_3 \\ C_2\,H_3 \end{array} \right.$$

which is characterized by its odour of sea-fish. It was observed by him during the distillation of a large quantity of human urine.

part of the ammonia unites with the phosphate of magnesia of the urine, and large quantities of beautiful crystals of phosphate of magnesia and ammonia are thrown down. (*Plate II. Figs.* 3, 5.) This particular decomposition is closely related to the formation of sediments, and I shall, therefore, have occasion to refer to it again.

The urea is by far the most important of the constituents of the urine. We have already seen that it is, essentially, the final product of the retrograde metamorphoses of the tissues. It is the medium through which the nitrogen, which has become useless to the body, is again restored to the inorganic world. Separated from the body, and brought into contact with decomposing and putrefying matters, urea is readily converted into ammonia and carbonic acid, and under these forms becomes food for plants, and so again commences its circuit of changes.

Uric acid stands next in importance to urea, and is likewise the product of the decay of the nitrogenous constituents of the body. As a chemical compound, it must be placed above urea, being, by oxidation, finally converted into urea and carbonic acid. The quantity of it in the urine is considerably less than that of urea; and, unlike urea, it is not found free in the urine, but combined with bases, particularly with soda.

Besides uric acid, we also meet with small quantities of hippuric acid in urine. The source of the hippuric acid has not yet been determined; but it is very probable that it is formed, like urea and uric acid, from the retrogressive metamorphoses of the tissues. In addition to these compounds, urine always contains a small quantity of xanthine and creatinine—substances which are also found in the juice of flesh—and colouring and extractive matters, of whose chemical nature, origin, &c., we unfortunately at present know very little. Of the mineral constituents, the phosphates, and especially the acid phosphate of soda, hold a conspicuous place in healthy urine. Small quantities of the earthy phosphates, phosphates of lime and phosphates of magnesia, and a considerable quantity of chlorides, viz. chlorides of sodium and potassium, with traces of chloride of ammonium, are also present in it. Lastly, we invariably find, as a constituent of urine, sulphuric acid, which, together with the phosphorus of the phosphatic salts, are derived chiefly from the sulphur and phosphorus of the used-up proteine-compounds of the body. A certain and, altogether, not an inconsiderable quantity of carbonic acid, derived from the blood which is continually passing through the kidneys, highly charged with that gas, is evacuated with the urine.

Traces of oxide of iron and of silicic acid are also found in the ashes of urine.

Besides these normal—organic and inorganic—constituents, the urine may contain *pathological* and *accidental* constituents. Of the numerous pathological constituents of urine, albumen, sugar, bile, and fat may be particularly mentioned; they appear in the urine as consequences of special diseased conditions of the body. The accidental vary much in kind, and are introduced into the body either accidentally or designedly. They are discharged from the urine either unchanged or after having undergone chemical decompositions. They will be specially treated of in the Fourth Part.

We shall now proceed to the more particular consideration of the different normal, organic and inorganic, as well as of the pathological and accidental, constituents of the urine.

THE NORMAL ORGANIC CONSTITUENTS OF THE URINE.

SECTION II.

UREA.

Composition :—

In 100 parts :	Carbon . . .	20·000
	Hydrogen . . .	6·666
	Nitrogen . . .	46·667
	Oxygen . . .	26·667
		100·000

Formula : $C_2H_4N_2O_2$. Rational formula $N_2\left\{\begin{matrix}C_2O_2\\H_2\\H_2\end{matrix}\right.$

A. *Occurrence.*—Urea exists in the urine of mammalia, of birds, and of reptiles, but is most abundant in the urine of carnivorous animals. It is also constantly present in the blood, and often in considerable quantities after extirpation of the kidneys, and in Bright's disease.

The fact of the quantity of urea increasing in the blood after extirpation of the kidneys, tends to show that this substance is formed in the blood and not in the kidneys—that it is, in fact, the product of the oxidation of unserviceable nitrogenous materials—the results of the wear and tear of the tissues, and also of the superfluous nitrogenous matters, which have been introduced into the blood. Urea does not exist in the juice of muscles, but it may be artificially obtained out of certain bodies—creatinine, xanthine, hypoxanthine, &c.—which are present in this juice. Consequently, we may assume, that this class of bodies (to which also the uric acid found in the blood belongs) is converted into urea and other compounds by the action of oxygen and the free alkalis, and then discharged from the body by the kidneys. Thus, uric acid, creatine, glycine, allantoine, guanine, theine, gelatine, and superfluous nitrogenous nutritive materials, when introduced into the blood, are converted into urea and other compounds, and so cause a rapid increase in the quantity of urea in the urine.*

Urea is also found in healthy blood, in the amniotic fluid, and in the vitreous and aqueous humours of the eye. Funke and others have found it to be a normal constituent of the sweat. Wurtz likewise found it in the lymph and chyle of different animals. It does not appear to be normally present in the muscles of man, and of the vertebrata generally; at least no one has yet succeeded in finding it there. It probably, however, exists in the muscles and organs of many of the lower animals. Notable quantities of it were found by Städeler and Frerichs in the muscles, and in almost all the organs of many cartilaginous fishes, whilst in the corresponding parts of bony fishes it was sought for in vain.

Urea is found in nearly all the fluids of the body, when its excretion through the kidneys is interfered with or suppressed. In such case, an increase of it is first observed in the blood, and after that it soon appears in the serous exudations; it has also been found in the bile and the saliva, in vomited matters, and even in pus and milk. Under such circumstances, the sweat also contains much urea, so that even a slight crust of urea may sometimes remain after the evaporation of the sweat (Schottin).

When urea is introduced into the body it is not decomposed under normal conditions, but is rapidly removed, so that in the course of a few minutes a distinct increase of the urea may be often observed in the urine. Gallois saw a rabbit weighing two kilogrammes killed by 20 grammes of urea; first of all, its respiration was retarded, then came on weakness of the limb, tremblings, twitchings, general convulsions, rigidity, and death.

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* I must here call attention to an interesting investigation into the physiological action of the spleen and the sources of the urea, by Führer and G. Ludwig, in the Archiv für Physiolog. Heilkunde, 1855. Heft 3 and 4. The authors offer, as the result of their researches, the following conclusion:—The urea, during normal nutrition, is essentially derived from the solution of the morphotic elements of the blood, and all superfluous food taken into the body occasions an excessive formation and destruction of these elements.

The urine of a healthy man, under mixed diet, contains on an average from 2·5 to 3·2 p. c. of urea; hence, from 22 to 35 grammes of it are discharged in the twenty-four hours. The quantity of the urea excreted, however, varies much, and is greatly influenced by the weight of the body and the food taken. Lehmann found the quantity of urea to amount to 58 grammes in the twenty-four hours under a purely animal diet, and to diminish to 15 grammes under a non-nitrogenous diet. The urea does not, however, wholly disappear from the urine, even when no food is taken.

There are several methods by which urea may be artificially produced. For example, cyanate of ammonia, which has an elementary composition similar to that of urea, is, when heated in solution, readily changed into urea. Urea may be also produced from creatine, allantoine, aloxan, oxamide, and many other bodies. Uric acid, when subjected to the action of powerful oxidising agents, yields, as its ultimate products, urea, carbonic acid, and water. Nathansen has lately discovered two other modes of forming urea, which seem to indicate that urea is probably an amide of carbonic acid. He obtained urea by heating carbonic ether with an excess of ammonia; and also by the action of chloro-carbonic acid on dry ammoniacal gas. I can corroborate both these facts.

B. *Preparation*:—1. *From the urine.*—Two volumes of urine are mixed with one volume of the solution of baryta, as used in the quantitative analysis of urea. The mixture is filtered, in order to remove from it the precipitate of phosphate and sulphate of baryta, which is formed, and is then evaporated to dryness in a water-bath. The residue is treated with alcohol, and, after filtration, evaporated to dryness. The saline products thus obtained are treated with pure alcohol. The solution now contains pure urea, which, on evaporation, crystallises in colourless needles. Should the urea not be perfectly colourless, it may be made so by subsequent treatment with pure animal charcoal.

2. *From cyanate of ammonia.*—Eighty grammes of anhydrous ferro-cyanide of potassium are heated over a gentle fire, with thirty grammes of carbonate of potass, until a portion of the mass, on trial, hardens into a colourless glass. The crucible containing

the mixture is then removed from the fire, and 150 grammes of red-lead are added to it very gradually, and in small quantities at a time; the mass is again heated about ten minutes, and kept constantly stirred, and then poured upon an iron plate. When it has cooled, the crude cyanate of potass is moistened with a solution of 80 grammes of sulphate of ammonia in 400 to 500 grammes of water, and when all of it is dissolved, the solution is filtered and evaporated to dryness. The dried saline mass is then treated, and several times digested, with small portions of alcohol (100 to 200 grammes, 30^{0}_{0}); the solution is filtered, the alcohol separated by distillation, and the residue then left to crystallise.

C. *Microscopical characters.*—When pure urea is rapidly deposited from a concentrated solution, it appears, under the microscope, in the form of white, shining, silky needles. But when the crystallisation takes place slowly in a weak solution, beautiful silky, white, nearly transparent, shining, striated, four-sided prisms, terminated by one or two oblique facets, are formed. (Funke, *Plate II. Fig.* 4.)

D. *Chemical characters.*—Urea has a bitterish, cool taste, resembling that of saltpetre. Its crystals contain no water, are permanent in the air, and readily dissolve in water and in alcohol. Its solutions are neutral. In ether it is almost wholly insoluble.

1. When urea is moderately heated on platina, it melts and gives off ammonia; but when the heat is increased it becomes solid again, takes a brown colour, and is at last completely consumed, leaving no trace of carbon behind.

When the heat is carefully applied, much ammonia is given off at 150° to 160° C. (302° to 320° Fahr.); and the remains of the previously melted urea harden into a mass of cyanuric acid $3\,(C_2\,H_4\,N_2\,O_2) = (C_6\,H_3\,N_3\,O_6 + 3\,N\,H_3)$, with which are mixed small quantities of other products of the decomposition (ammelide $C_6\,H_4\,N_4\,O_4$ and biuret $C_4\,H_5\,N_3\,O_4$).

2. Urea is decomposed when heated with strong mineral acids, with sulphuric acid, for instance, or with caustic potass or soda, two equivalents of water being added to its elements, and carbonic acid and ammonia formed. (Quantitative analysis by Ragsky and Heintz.) It also undergoes a similar decomposition, first, when we add to its solution putrescible organic nitrogenous matters—the cause of the alkaline fermentation of the urine—and, secondly, when it has been exposed for a long time in a closed tube, to a

temperature above 100° C. (Fahr. 212°). (Quantitative analysis by Bunsen) $C_2 H_4 N_2 O_2 + 2 HO = 2 CO_2 + 2 NH_3$.

3. When nitrous acid, or a solution of nitrite of suboxide of mercury in nitric acid is added to a solution of urea, the urea is converted into water, carbonic acid, nitrogen, and ammonia. (Liebig, Wöhler, Ludwig, and Krohmeyer.) $C_2 H_4 N_2 O_2 + NO_3 + NO_5, HO = 2 CO_2 + 2 N + NH_4 O, NO_5 + HO$. Consequently 1 gramme of urea causes 1·2 gramme of gas to be given off.

4. A solution of urea heated with nitrate of silver yields an insoluble deposit of cyanate of silver, and the solution contains nitrate of ammonia. By this method we reconvert it into the same combinations (cyanic acid and ammonia), from which we obtain it artificially.

5. Oxide of mercury forms several definite combinations with urea, in which, according to circumstances, two, three, or four equivalents of the oxide of mercury are combined with one equivalent of urea. Oxide of silver forms a similar combination with urea, three equivalents of the oxide uniting with one of urea.

6. A solution of nitrate of mercury, added to a solution of urea, yields a white flocculent precipitate, the composition of which varies with the degree of concentration of the fluid. The precipitate may have a composition answering to either of the following formulæ:—

$$NO_5, \overset{+}{Ur} + 2 HgO$$

$$\text{or } NO_5, \overset{+}{Ur} + 3 HgO$$

$$\text{or } NO_5, \overset{+}{Ur} + 4 HgO$$

Corrosive sublimate, on the other hand, occasions no precipitate in weak acid solutions of urea; but in an alkaline solution it does so readily. Liebig's quantitative determination of the urea and of the chlorine is founded on this fact.

7. Urea mixed with a solution of hypochlorite of soda is converted into nitrogen, carbonic acid, and water. The carbonic acid is rapidly absorbed by the ley, so that the quantity of the urea may be determined directly by measurement of the nitrogen. (Davy.)

8. Urea, in an alkaline solution, energetically resists the oxidising agency of hypermanganate of potash; on the other hand, in hydrochloric acid solutions it readily decomposes, especially when heated, and is converted into carbonic acid and ammonia. This property of urea tends to indicate that it is the final product of the retro-

gressive metamorphoses of the tissues; for in an alkaline solution, and so, therefore, in normal blood, it is not oxidised by oxidising agents. Hereby, also, it is essentially distinguished from uric acid, creatine, guanine, &c., which are, in a manner, one step higher in composition. Urea also remains unaffected when in contact with ozone, under whose influence uric acid is rapidly decomposed and urea produced.

9. Just as urea arises from the union of cyanic acid and ammonia, so likewise are compound ureas—combinations perfectly analogous to ordinary urea-compounds—formed when cyanic acid is combined with the homologous bases of alcohol radicles instead of ammonia, for example, with ethylamine:

$$\text{Thus, } N\left\{\begin{matrix} C_4\,H_5 \\ H \\ H \end{matrix}\right. \text{ instead of with ammonia } N\left\{\begin{matrix} H \\ H \\ H \end{matrix}\right.$$

These combinations exactly correspond to urea, excepting only that a part of the hydrogen is replaced by the alcohol-radicles—for example, by ethyl $C_4\,H_5$, by methyl $C_2\,H_3$, &c.

Thus, we have:

$$\text{Urea} \quad . \quad . \quad . \quad C_2\left\{\begin{matrix} H \\ H \\ H \\ H \end{matrix}\right. N_2\,O_2$$

$$\text{Ethyl-urea} \quad C_2\left\{\begin{matrix} C_4\,H_5 \\ 3\,H \end{matrix}\right. N_2\,O_2$$

$$\text{Dimethyl-urea} \quad C_2\left\{\begin{matrix} C_2\,H_3 \\ C_2\,H_3 \\ 2\,H \end{matrix}\right. N_2\,O_2$$

$$\text{Ethylmethyl-urea} \quad C_2\left\{\begin{matrix} C_2\,H_3 \\ C_4\,H_5 \\ 2\,H \end{matrix}\right. N_2\,O_2 \qquad \&c.$$

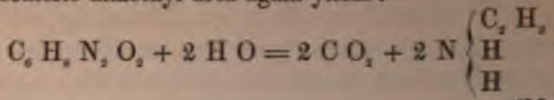
All these compounds resemble urea; they yield, with nitric acid, salts difficult of solution; and by the action of potash two equivalents are decomposed into carbonic acid and two equivalents of base.

For example: Ethyl-urea $C_6\,H_8\,N_2\,O_2$.—

$$C_6\,H_8\,N_2\,O_2 + 2\,H\,O = 2\,C\,O_2 + N\left\{\begin{matrix} H \\ H \\ H \end{matrix}\right. + N\left\{\begin{matrix} C_4\,H_5 \\ H \\ H \end{matrix}\right.$$

(Ethylamine).

The isomeric dimethyl-urea again yields:—



$$C_6\,H_8\,N_2\,O_2 + 2\,H\,O = 2\,C\,O_2 + 2\,N\left\{\begin{matrix}C_2\,H_3\\H\\H\end{matrix}\right.$$

(Methylamine).

10. Urea forms crystallisable compounds with many salts—with corrosive sublimate, chloride of sodium, nitrate of lime, chloride of calcium, &c. It likewise produces, with many acids—such as succinic, tartaric, citric, and gallic acids—as well as with inorganic acids, crystallisable salts, two of which, the nitrate and oxalate, are of especial interest.

a. Nitrate of urea.—$C_2\,H_4\,N_2\,O_2,\ N\,O_5,\ H\,O$. A concentrated solution of urea, mixed with pure moderately concentrated nitric acid, free from nitrous acid, throws down, on cooling, white, shining plates or scales. These are for the most part single, but some of them are massed together, overlying one another.

When the quantity of urea is small, the formation of the salt may be observed under the microscope, and in the following way:—one end of a little bit of thread is laid in the drop which is to be tested for urea; the drop itself and one-half of the thread is then covered with the glass, and the other end of the thread moistened with a drop of pure nitric acid. In this way, two fluids being gradually mixed together, the formation of crystals goes on very regularly on both sides of the thread which is under the glass; so that we can examine the crystals during formation. First of all, we observe rhombic plates or short prisms, whose acute angles measure 82°, as well as numerous complicated forms. The forms by removal of their obtuse angles and by flattening are converted into hexagonal plates or six-sided prisms. The development of these crystals, however, only goes on regularly when the processs is slow. When the crystallisation is rapidly conducted numerous six-sided tile-shaped plates, superimposed the one on the other, are formed. Obtuse octahedra with a rhombic base, of slight durability, and having an acute angle of 82°, are also frequently formed at the moment when the two fluids come in contact; other crystals are also rapidly deposited on these, and hence the primitive octahedra pass into the rhombic or hexagonal plates before-mentioned. Lastly, we notice very characteristic twin-crystals, which, from a peculiar arrangement, difficult of description, result in crystalline formations, which very closely resemble the well-known forms of gypsum. (*Plate II. Fig.* 6.)

This salt remains unchanged in the air, dissolves freely in water, but not readily in water mixed with nitric acid, and scarcely at all in alcohol containing nitric acid. Rapidly heated on platina-foil it detonates, and at 140° C. (Fahr. 284°) is decomposed into carbonic acid, nitrous oxide, urea, and nitrate of ammonia.

On mixing a concentrated solution of nitrate of urea with oxalic acid, the second compound, oxalate of urea, is precipitated.

b. Oxalate of urea.—$2\,(C_2\,H_4\,N_2\,O_2), C_4\,O_6 + 4\,HO$. This compound, also formed by the mixture of oxalic acid with a concentrated solution of urea, is deposited in the shape of long thin plates or prisms. When the formation of the crystals is observed under the microscope, they usually appear in the form of hexagonal plates, like those of nitrate of urea, and, more rarely, as four-sided prisms. (Funke, *Plate II. Fig.* 6.)

Oxalate of urea dissolves readily in water, but is precipitated from its solution on the addition of an excess of oxalic acid. It is decomposed by heat into carbonate of ammonia and cyanuric acid.

E. *Tests.*—To demonstrate the presence of urea in urine, it is sufficient, in most cases, to evaporate a small quantity (15 to 20 grammes) of urine to the consistence of syrup, in a water-bath; this residue is then repeatedly washed with alcohol, so long, in fact, as a drop of the solution, evaporated on a watch-glass, leaves any trace behind it. The urea is now contained in the alcoholic solution, and when the spirit has been driven off in a water-bath, is left as a more or less impure residue. Dissolved in a little water, and treated partly with pure nitric acid and partly with a concentrated solution of oxalic acid, it forms the two above-mentioned compounds. When very minute quantities are used, the crystallisation of nitrate of urea may be observed under the microscope—the crystalline forms, described above under the head of *Nitrate of Urea,* being produced. Any albumen contained in the urine must be first of all separated by the addition of a drop of acetic acid and boiling; the solution is then filtered and treated as already described. This process must always be followed when urea is sought for in the blood.

SECTION III.

Creatine.

Composition :—

In 100 parts :	Carbon	36·64
	Hydrogen . . .	6·87
	Nitrogen . . .	32·06
	Oxygen . . .	24·43
	(Anhydrous) .	100·000

Formula : $C_8\,H_9\,N_3\,O_4 + 2\,HO$.

A. *Occurrence.*—Creatine is found in the juice of muscles both striped and unstriped, in quantities varying from 0·07 to 0·32 p. c. Scherer found only 0·0388 p. c. in horse-flesh. According to Verdeit and Marcet traces of it exist in the blood. W. Müller and Lerch also found it in the brain; but it has not yet been discovered in the glandular organs. With regard to its presence in the urine, the reader is referred to what is said under the head of Creatinine.

Little positive is known concerning the physiological import of creatine. Its presence in the juice of muscle, and its highly nitrogenous composition would lead us to regard it as an important agent of nutrition; but its ready conversion into urea, creatinine, and sarcosine (all of which are undoubtedly to be considered as excretions), gives to it rather the character of an excretion, holding a position, in the stages of retrogressive tissue-metamorphoses somewhat midway between the most complex proteine-bodies, and the simpler forms (urea, &c.). Creatine, therefore, is more nearly related to urea than to proteine-bodies.

B. *Preparation.*—Flesh finely chopped, or rubbed down with rough glass-powder is mixed with an equal, or one and a-half times its volume of spirits of wine, gently heated in a water-bath, and its fluid then expressed. The spirits of wine is first of all distilled off from this fluid, and the remainder carefully precipitated by acetate of lead. The filtrate is then freed from lead by sulphuretted hydrogen, and, when separated from sulphide of lead, is evaporated to the consistence of syrup in a water-bath. The crystals which separate are collected after an interval of a few days, freed from their mother-ley by being laid on blotting-paper, and then crystallised out of hot water.

C. *Microscopic characters.*—Pure creatine forms colourless, perfectly transparent, glistening crystals, which belong to the monoclinic system. (Funke, *Plate III. Fig.* 1.) They are usually disposed in groups, somewhat similar to those assumed by sugar of lead.

When a dilute solution of creatine is placed in a concave object-glass, and allowed to evaporate spontaneously, we first observe at the border of the fluid a formation of long prismatic crystals, which are thickest at their free extremities, and gradually become thinner towards their other ends. Towards the centre of the fluid very regular crystals are gradually formed, and in particular prisms, which are often united together at their acute angles in a fan-like shape. A few crystals here and there in the middle present a characteristic bulging-out, similar to that of lactate of zinc: these become thinner towards their extremities, and are bounded by two plain surfaces. There also often appear thick, apparently rectangular plates, sometimes singly, and sometimes in larger numbers.

D. *Chemical characters.*—Creatine has a bitter, pungent taste. It dissolves in 75 parts of cold water. Boiling water takes up a much larger quantity of it, but as it cools, the creatine separates in the form of shining crystalline needles. Alcohol takes up only 1 in 9410 parts; and in ether it is completely insoluble. Its aqueous solution has no action on vegetable colours, has a bitter taste, and very readily undergoes decomposition. Dessaignes has recently succeeded in forming crystallisable compounds of creatine with sulphuric, hydrochloric, and nitric acids.

2. When creatine is boiled for a long time in a solution of baryta, it is converted into urea and sarcosine:

$$\underset{\text{(creatine)}}{C_8\,H_{11}\,N_3\,O_6} = \underset{\text{(urea)}}{C_2\,H_4\,N_2\,O_2} + \underset{\text{(sarcosine);}}{C_6\,H_7\,N\,O_4}$$

and if the boiling be continued still longer, the urea is changed into carbonic acid and ammonia, the ammonia escaping, and the carbonic acid uniting with the baryta. The sarcosine may be obtained, though with difficulty, in the form of colourless crystals.

3. Creatine dissolves without change in dilute mineral acids; but when boiled in concentrated acids, it gives off water, and is converted into creatinine:

$$\underset{\text{(creatine)}}{C_8\,H_{11}\,N_3\,O_6} - 4\,H\,O = \underset{\text{(creatinine).}}{C_8\,H_7\,N_3\,O_2}$$

4. Chloride of zinc produces no precipitate with perfectly pure creatine. (Schlossberger).

5. Creatine is not affected by the action of peroxide of lead; but it is decomposed by permanganate of potass; the products, however, of this decomposition are, with the exception of carbonic acid, unknown. It is possible that urea may be one of the products formed.

6. When a solution of creatine is boiled with an excess of oxide of mercury, carbonic acid is evolved with separation of metallic mercury, and the solution contains the oxalate of a powerful base of methyluramine ($C_4\,H_7\,N_3$), which, according to Dessaignes, is to be considered as a conjugate of urea and methylamine, effected with separation of water.

$$C_4\,H_7\,N_3 + 2\,H\,O = \underset{\text{(Urea)}}{C_2\,H_4\,N_2\,O_2} + \underset{\text{(Methylamine).}}{N\begin{cases}2\,H.\\ C_2\,H_3\end{cases}}$$

E. *Tests.*—(See Creatinine.)

SECTION IV.

Creatinine.

Composition :—

In 100 parts :	Carbon	42·48
	Hydrogen . . .	6·19
	Nitrogen . . .	37·17
	Oxygen . . .	14·16
		100·000

Formula : $C_8\,H_7\,N_3\,O_2$.

A. *Occurrence.*—Creatinine is the most powerful organic base met with in the body; it was first discovered by Liebig in the crystalline precipitate, which Heintz, and after him, Pettenkofer, obtained by the action of a solution of chloride of zinc on concentrated urine. Liebig found creatine, as well as creatinine, in this chloride of zinc compound, and was consequently led to the conclusion that both these bodies exist originally in the urine. Heintz, however, afterwards showed, by carefully-conducted experiments, that fresh urine does not contain creatine. He found that the creatine is formed through the decomposition of the chloride of zinc compound, the creatinine of which takes up water and is converted into creatine. This view has been since confirmed by Liebig and Dessaignes. Again, creatine is readily converted into creatinine by abstraction of its water, and therefore the creatine which is always found in the juice of flesh, may be converted into creatinine by the loss of water either in the flesh itself or more probably in the blood, and thus be eventually discharged with the urine in the form of creatinine.

Lehmann considers, rightly enough, that further investigation is required to show whether the creatine of muscle is invariably converted into creatinine, and thus evacuated, or whether it may not also assist in the formation of urea; the latter view is in some degree favoured by its ready conversion into sarcosine and urea when boiled with baryta-water. Dessaignes, on the other hand, is of opinion that the juice of muscle originally contains creatinine only, like the urine; and that it is only after its separation, and under the long-continued action of heat, that the greater part of it is converted into creatine in the neutral fluid. But this view I cannot accept. By Städeler's new method, creatine is obtained from muscle so readily and in such a pure state, that it is difficult to conceive how, in so short a time, the greater part of the creatinine can be converted into creatine by the taking up of water.

According to my own observations, 0·6 to 1·3 gramme of creatinine is passed by a healthy man, living on a good mixed diet, in an average quantity of from 1500 to 1600 C. C. of urine, during the twenty-four hours.

Verdeil and Marcet found creatinine in the blood as well as in the urine of man and the juice of muscle; Socoloff found it in the urine of horses and of sucking-calves; Dessaignes, in the urine of the cow; Liebig, in that of the dog. According to Scherer, it is also present in the amniotic fluid.

B. *Microscopic characters.*—Creatinine crystallises in the form of very glistening, colourless prisms, which belong to the monoclinometric system. (Funke, *Plate III. Fig.* 2. 2nd Edit. IV. 5.)

C. *Chemical characters.*—Creatinine forms the strongest organic base met with in the animal kingdom. Its taste is almost as pungent as that of ammonia. It is soluble in eleven parts of water, at 12° to 20° C. (Fahr. 54° to 68°), and in a much less quantity of boiling water. 100 parts of cold alcohol dissolve about one part of creatinine. Boiling alcohol takes up a larger quantity, which is separated again in crystalline masses, as the alcohol cools. Ether dissolves only a very small quantity of it. Its solutions have a strongly alkaline reaction, and a caustic taste, like that of dilute ammonia.

Creatinine behaves like a nitrile base; it unites directly with 1 eq. of iodide of ethyle, and so passes into iodide of ethyle-creatinine, from which, by treatment with oxide of silver the ethyle-creatinine is separated as a powerful base, and may be obtained in a crystalline form.

1. A concentrated solution of chloride of zinc, added to a solution of creatinine, immediately throws down a crystalline precipitate. When very slowly formed, the crystals are distinctly prismatic; but when quickly produced, and as seen under the microscope, fine needles are observed concentrically grouped together, forming either perfect rosettes, or tufts which cross each other, or of which each two

are connected by their short stalks, so as to resemble brushes passing one into the other.

When creatinine is separated by chloride of zinc from the watery extract of urine, the compound is obtained for the most part in the form of dark warty masses, which show very little of a crystalline structure even under the microscope. Sometimes, however, distinct crystalline glands, fine needles, united together in brush-like and stellate masses may be recognised. From the alcoholic extract of urine, precipitated with an alcoholic solution of chloride of zinc, the creatinine-chloride of zinc compound is always obtained in the form of a pale, yellowish powder, which, under the microscope, is found to consist almost wholly of yellowish, transparent, well-defined globules or balls of different sizes. Upon these globules, under high magnifying powers (400 diameters), distinctly-marked striæ are observed. On dissolving a little of the powder in boiling water, the production of regular crystalline forms may be observed under the microscope. A drop of the solution, when nearly cold, is placed upon the object-glass, and a little solution of chloride of zinc added to it by means of a thread, and in the manner above-described under the head of Nitrate of Urea, p. 14. The formation of crystalline glands, already described as characteristic of creatinine-chloride of zinc, often of considerable size, is soon observed on both sides of the thread.

2. A moderately concentrated solution of creatinine, mixed with an equally concentrated solution of nitrate of silver, coagulates into a network of acicular crystals, which are soluble in boiling water, but separate from it as it cools.

3. Corrosive sublimate throws down a curd-like precipitate, which in the course of a few minutes is converted into a confused mass of fine colourless crystals.

4. A solution of protonitrate of mercury does not at once produce a precipitate in a dilute solution of creatinine; but if a solution of carbonate of soda is added guttatim until it becomes permanently cloudy, the compound ($C_8 H_7 N_3 O_2, N O_5 + 2 Hg O$) soon appears in the form of beautiful microscopic crystals. The precipitate is readily formed in concentrated solutions; and, if no free nitric acid is present, without the addition of soda.

5. Ammonia is evolved when creatinine is heated with an ammoniacal salt.

6. Creatinine forms with hydrochloric, nitric, and sulphuric acids, compounds which are soluble in water, and crystallise readily :—

a. Hydrochlorate of creatinine crystallises in the form of transparent prisms and broad plates. With bichloride of platinum it yields a compound similar to that with potash and ammonia; but this compound is very soluble and crystallises in crimson prisms.

b. Sulphate of creatinine yields concentrically grouped, transparent, square tables.

It is especially to be noted that creatinine-chloride of zinc—the most important compound of creatinine—is not precipitated from hydrochlorate of creatinine, &c., on the addition of a solution of chloride of zinc. The separation, however, at once takes place, if, before the addition of the chloride of zinc solution, a sufficiency of acetate of soda is mixed with the creatinine-salt.

7. Under the action of protoxide of mercury, peroxide of lead and sulphuric acid or permanganate of potash, creatinine, as well as creatine, is converted into oxalic acid and oxalate of methyluramine ($C_8H_7N_3O_2 + 4\,O = C_4H_7N_3 + C_4O_6$).

8. Creatinine is produced from creatine by the action of mineral acids, the creatinine losing 4 equivalents of water. But when a solution of creatinine, in which an alkali is present, is allowed to stand for some time, the creatinine takes up water, and again passes into the form of creatine. Heat favours this transformation. (Liebig, Dessaignes.)

D. *Tests.*—As urine contains only a small quantity of creatinine, a large amount of the fluid is required for its successful demonstration. In most cases, however, from 200 to 300 C. C. suffice for its qualitative analysis. Fresh urine is neutralised with a little milk of lime, and the phosphoric acid then thrown down by a solution of chloride of calcium. The precipitate is separated by filtration, and the filtered fluid quickly evaporated to dryness in a water-bath. The residue thus obtained is extracted with strong, or, best of all, with absolute alcohol, allowed to stand for some hours, and filtered; the clear fluid is then treated with a few drops of a concentrated solution of chloride of zinc free from acid. The mixture, after being well shaken, soon becomes turbid, and the separation of the creatinine-chloride of zinc is completely effected in forty-eight hours. The compound is washed on a filter with spirits of wine, dried, and microscopically examined. (See C. 1.)

To obtain the creatinine in a pure state, the compound is dissolved in a small quantity of boiling water, and the oxide of zinc and hydrochloric acid separated by boiling the fluid for at least a quarter of an hour with freshly-precipitated and well-washed hydrated oxide of lead. The filtered liquid is rendered colourless by boiling with animal charcoal, and evaporated to dryness. The residue, which always consists of a mixture of creatinine and creatine, is then treated with cold strong spirits of wine, whereby the creatinine is dissolved and the creatine left. On evaporation of this spirituous solution we obtain pure crystals of creatinine; the creatine may also be readily obtained in a pure form from the part of the residue which was insoluble in alcohol, by re-crystallisation, out of a little boiling water. It should be observed, however, that when a very dilute solution of creatinine-chloride of zinc is treated with oxide of lead, creatine alone, and no creatinine whatever is found in the residue. The creatinine, in a dilute solution and under long exposure to heat, passes again into the state of creatine by taking up 4 equivalents of water.

Should the urine operated upon contain albumen, the albumen must be previously separated from it by coagulation.

Creatinine is distinctly characterised by its strong basic properties, by its readiness to form double compounds with metallic salts, and salts with acids. It is, moreover, distinguished from creatine by its much greater solubility in alcohol, and by the form of its crystals.

The characters of creatine are not so well marked; we have, in fact, no other more certain test of it, than what we obtain through a comparison of it with pure creatine, its crystalline form, &c.

SECTION V.

XANTHINE.

Composition :—

In 100 parts:		
	Carbon	39·5
	Hydrogen	2·6
	Nitrogen	36·8
	Oxygen	21·1
		100·0

Formula: $C_{10}\,H_4\,N_4\,O_4$.

A. *Occurrence.*—Xanthine, until recently, was only known as a very rare constituent of certain urinary calculi. Scherer and Städeler have, however, now shown that it is widely distributed throughout the animal economy. Scherer found xanthine in the human urine, in the spleen, the pancreas, and the brain; in ox's liver, the thymus-gland of the calf, and the muscles of the horse, of the ox, and of fishes; he also found it in an enlarged spleen and in the liver, in a case of yellow atrophy of the liver. The xanthine was generally found associated with hypoxanthine, and in the spleen, the liver, and the brain, with uric acid also.

B. *Microscopic characters.*—Xanthine is amorphous, and presents no crystalline form under the microscope. It is usually deposited, from its boiling watery solution, in the form of colourless flakes, sometimes also as a fine powder, presenting the appearance of minute roundish granules under the microscope; these granules, in the flocculent precipitate, are grouped together, and in the powdery precipitate remain separate.

C. *Chemical characters.*—Xanthine forms hard white masses, which assume a shining, waxy appearance when rubbed with the nail. It is almost insoluble in cold, but slightly soluble in boiling water. It has been artificially prepared from guanine.

1. Xanthine is soluble in ammonia, potash-ley, and in hydrochloric, nitric, and sulphuric acids. From the alkaline solutions it is precipitated on the addition of an acid; and with the acids it forms crystalline compounds.

2. A cold, saturated aqueous solution of xanthine, treated with corrosive sublimate, yields a white precipitate. When boiled with acetate of copper, yellowish-green flakes are thrown down. Its ammoniacal solution is precipitated by chloride of cadmium and chloride of zinc, as well as by acetate of lead. This last precipitate, on standing, often takes the form of shining scales.

3. Nitrate of silver, added to the nitric acid solution of xanthine, occasions a flocculent precipitate, which is dissolved by boiling, and again precipitated as the solution cools. The silver-compound, when quickly cooled, shows, under the microscope, a confused mass of fine crystalline needles; when slowly cooled, however, it yields wavellite-like aggregations of fine crystals.

Nitrate of silver, added to an ammoniacal solution of xanthine, produces a gelatinous precipitate, which is insoluble in ammonia. $C_{10}\,H_4\,N_4\,O_4 + 2\,Ag\,O$.

4. Xanthine, when heated with nitric acid, is dissolved without evolution of gas. The solution on evaporation yields a yellow residue, which is not rendered purple by ammonia; caustic potash gives to the residue a reddish-yellow colour, which becomes a beautiful violet-red when heated.

5. Xanthine dissolved in hot, strong hydrochloric acid, yields, if allowed to cool slowly, beautiful microscopic crystals of hydrochlorate of xanthine, which form six-sided plates, lying together in groups

and glandular masses. Very frequently, however, only round and egg-shaped forms are met with. The nitrate has a similar, though not so characteristic a form of crystallisation; and here, again, we observe glands of rhombic plates and prisms.

D. *Tests.*—Fresh, healthy urine, in quantity not less than from 100 to 200 pounds, is evaporated in a water-bath to from one-sixth to one-eighth of its original volume, and its phosphoric acid removed by precipitation with baryta-water. The filtrate is again evaporated until the salts are crystallised out of it; the mother-liquor thus obtained is then well diluted with water, a solution of acetate of copper added, and boiled for some time. A dirty-brownish precipitate is thus obtained, which is first decanted and then washed on the filter with cold water until all chlorine-reaction has disappeared. By treating this precipitate with hot nitric acid, we obtain a brownish solution, from which the impure xanthine-silver compound is precipitated by nitrate of silver. The crystalline compound, after being washed, is dissolved in boiling dilute nitric acid; any remaining flocculi of chloride of silver removed by filtration, and the filtrate set aside and allowed to crystallise slowly. The collected crystalline silver-compound is freed from nitric acid by digestion with an ammoniacal solution of silver; the washed precipitate diffused through water, boiled, and the compound decomposed by sulphuretted hydrogen. The boiling filtered solution deposits, when concentrated, coloured flocculi of xanthine, and the remainder is obtained by further evaporation. The preparation thus obtained is, however, always much discoloured; but by solution in strong hydrochloric acid and treatment with animal charcoal, the purification is readily effected. The filtrate, thus freed from colour, yields, when evaporated, hydrochlorate of xanthine, from which pure xanthine, with all its peculiar characters, may be obtained by repeated treatment with ammonia, and by subsequent removal of the chloride of ammonium by washing with cold water.

The quantity obtained is, after all, very small; from 600 pounds of urine I collected, after previous removal of the creatinine, very little more than one gramme of pure xanthine.

SECTION VI.

URIC ACID.

Composition :—

In 100 parts :	Carbon	35·714
	Hydrogen . . .	1·191
	Nitrogen . . .	33·333
	Oxygen . . .	19·048
	Water	10·714
		100·000

Formula : $C_{10} H_2 N_4 O_4 + 2 H O$.

A. *Occurrence.*—Uric acid is present in the urine of entire classes of animals, and in some animals of a very low class. The excrements of birds (guano), of snakes, of reptiles, and of insects, contain much uric acid. It has also been found in the blood, especially after extirpation of the kidneys, by Strahl and Lieberkühn,* and more recently by Garrod.† According to Garrod, the quantity of it in the blood is always increased in cases of gout. Moreover, it has been found in the spleen, the parenchyma of the lungs and the liver of the ox, as well as in gouty deposits.

The quantity of uric acid in human urine depends less upon the nature of the food than upon special conditions of the internal organs of the body; in this respect it differs from urea. The quantity of uric acid excreted in twenty-four hours by a healthy man, under normal circumstances is, according to Becquerel, between 0·495 and 0·557 gramme. In some experiments which I lately made on a vigorous young man, twenty-three years of age, 0·827 gramme of uric acid was passed in twenty-four hours, with 36·4 grammes of urea in 2,000 C. C. of urine. Further observations have shown me, that the quantity of uric acid differs much at different times, and may vary as much as from 0·2 gramme to 1 gramme in the twenty-four hours. According to Ranke, the relative quantity of the uric acid to the urea varies from as 1 : 50 to 1 : 80 in the twenty-four hours. An increase of uric acid in the urine is caused especially by derangement of the digestion, and also by defective nutrition. It is, likewise, increased in all febrile conditions of the body, and in affections of the lungs. The ready decomposition of uric acid by oxidising agents seems clearly to indicate, that its origin in the body has a close connexion with the respiratory process. Many facts favour this idea. Liebig, when he discovered cyanuric acid in the urine of a dog, observed, that no uric acid whatever was present in it; but Lehmann, on the other hand, has distinctly demonstrated its presence in the blood of a dog. Such a condition, however, undoubtedly occurs in other animals: in the urine of the pig and of the monkey, for instance, neither Bossingault nor Bibra could find uric acid.

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* Strahl und Lieberkühn. Harnsäure im Blute, etc. Berlin, 1848.

† Dr. Garrod on Gout, &c.

Much smaller quantities of uric acid, exist in the urine of carnivorous animals than in human urine; Vauquelin,* indeed, found the urine of a lion, entirely free from uric acid. According to Lehmann, however, when this animal is deprived of its freedom, and shut up for a long time in a cage, uric acid appears in considerable quantity in its urine,—as happens to man under like conditions,—and is separated from the urine as an acid urate of soda. Städeler, moreover, has succeeded in demonstrating the presence of allantoine in dog's urine, when the respiration of the animal was impeded.

Uric acid, when introduced into the healthy body, is converted into carbonic acid and urea; but should the oxidising processes of the body be in any way retarded, as happens during sleep, it will also produce oxalic acid. Uric acid may be considered as a twin excretion with urea; but its more intimate constitution has not yet been ascertained, notwithstanding that very great labour has been bestowed upon the subject. A series of highly interesting products of its decomposition have, however, been discovered. This much we may conclude, from the chemical characters of uric acid, viz., that it is, like creatine, one of the representatives of the retrogressive metamorphoses of the nitrogenous constituents of the body; and that it stands higher in the scale than urea, being itself, by oxidation, converted into carbonic acid and urea. That it undergoes, at least in part, similar changes in the animal organism, appears almost certain from the demonstrated fact of the presence of uric acid in the liver and spleen of herbivorous animals, in whose urine it is entirely absent.

B. *Preparation.* 1. *From human urine.*—Urine freshly voided in the morning, is filtered and mixed with hydrochloric acid (20 C. C. to 1 litre of urine), and allowed to stand for forty-eight hours.

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* Schweiger's Journ. V., p. 175.

The uric acid is, in this manner, separated in crystals, more or less coloured, and fitted for microscopic study.

2. *From the excrements of serpents.*—The fæces of a serpent are boiled with a solution, containing one part of caustic potash in twenty parts of water, until they have lost their ammoniacal smell. Carbonic acid is then passed through the filtered solution, until it has almost entirely lost its alkaline reaction; acid urate of potash is thus separated, and is collected and washed with water. After washing, the potash-salt is dissolved in a solution of potash, and then filtered into dilute hydrochloric acid, care being taken, that there be an excess of the acid; the precipitate formed is pure uric acid, which, after washing and drying, appears as a fine, light powder.

C. *Microscopical characters.* — Uric acid appears under the microscope in several forms, but usually as smooth, rhomboidal tables, which are sometimes coloured, always remarkably transparent and of different, sometimes of considerable size. These tables often undergo modification in form; thus, spindle-shaped figures result from the rounding off of their obtuse angles, and, with these, short, cask-shaped cylinders are frequently mingled.

Hexagonal plates, rectangular tables, or right rectangular four-sided prisms, with horizontal terminal planes, are also often met with; the last are frequently peculiarly disposed, being grouped together in glandular-shaped rosettes. Besides these, there are other forms, saw-like, fan-shaped, and dentated crystals, &c. (*Plate I. Figs.* 2 *and* 3; *Plate II. Fig.* 4; *Plate III. Fig.* 1.)

I have obtained many different forms of uric acid crystals, by mixing normal urine with varying quantities of hydrochloric acid; the nature of these crystals is readily ascertained, by comparing them with the crystalline forms given by Funke. Any doubt existing as to the nature of particular crystals, may be readily removed, by converting them into some more ordinary form of uric acid. The crystals are dissolved on the object-glass of the microscope, in a little caustic potash; and, on the addition of a drop of hydrochloric acid, crystals of the more ordinary form, table-, or spindle-shaped, soon appear.

D. *Chemical characters.*—Pure uric acid, obtained from the excrement of serpents, consists of white, softish, and excessively light, crystalline scales, which present, under the microscope, the forms above described. It has neither taste nor smell; is very slightly soluble in water, one part of uric acid requiring 14,000 to 15,000 parts of cold, and 1,800 to 1,900 parts of boiling water for its solution. The solution does not redden litmus. It is very little soluble in dilute hydrochloric acid, and quite insoluble in alcohol and ether. It is readily dissolved, without decomposition, in concentrated sulphuric acid, but is thrown down from the solution on the addition of water.

1. Uric acid is readily dissolved in a solution of phosphate of soda, and also in several other salts of the alkalies. It takes from these salts, and combines with, a part of their base, and so occasions the formation of acid salts. It is in this way that acid phosphate of soda, which is the chief cause of the acid reaction of the urine, is formed. By dissolving uric acid in a warm solution of phosphate of soda, it is easy to obtain a fluid, having a similar acid reaction to that of the urine, from which, on concentration, urate of soda is deposited in crystals. (For the separation of this last salt from the urine, see *Sediments.*)

2. Uric acid, heated in a glass tube, is decomposed without undergoing previous fusion. It is converted into urea and cyanuric acid (which are sublimed in the form of a ring), hydrocyanic acid, and a little carbonate of ammonia, whose presence is easily recognised by its smell. Besides these, peculiar oily products appear, and a porous coal containing nitrogen remains as a residue.

3. Uric acid made into a thickish paste with water, and boiled with peroxide of lead, is decomposed into four bodies: carbonic acid, allantoine, urea, and oxalic acid. The allantoine (which exists naturally in calves' urine) and the urea may be readily recognised by their mode of crystallisation; the oxalic acid remains in combination with the oxide of lead, and the carbonic acid escapes with effervescence. According to Pelouze, a small quantity of allanturic acid is formed at the same time. It is not improbable that the urea resulting from this decomposition is a product of a further oxidation of the allantoine, and the carbonic acid of the oxalic acid, so that the simple decomposition of uric acid by peroxide of lead yields only allantoine ($C_8 H_6 N_4 O_6$) and oxalic acid.

$$\underset{\text{(Uric acid.)}}{C_{10} H_4 N_4 O_6} + O + 2\,HO = \underset{\text{(Allantoine.)}}{C_8 H_6 N_4 O_6} + C_2 O_3$$

4. When one part of uric acid is gradually mixed with four parts of concentrated nitric acid (1·42 sp. gr.), the uric acid is dissolved with effervescence, and the whole solution at last con-

verted into a crystalline mass. The uric acid is decomposed into alloxan and urea. The uric acid is separated in crystals, but the alloxan, in consequence of the simultaneous formation of nitrous acid, is immediately decomposed into carbonic acid and nitrogen, which escape with effervescence.

In the formation of alloxan and urea from uric acid, two equivalents of water and two of oxygen are added to the uric acid:—

$$\underset{\text{(Uric acid.)}}{C_{10}H_4N_4O_6} + 2\,O + 2\,HO = \underset{\text{(Alloxan.)}}{C_8H_2N_2O_8} + \underset{\text{(Urea.)}}{C_2H_4N_2O_2}$$

Alloxan, when further treated with nitric acid, takes up two equivalents of oxygen, and is converted into two equivalents of carbonic acid, and one equivalent of parabanic acid:—

$$\underset{\text{(Alloxan.)}}{C_8H_2N_2O_8} + 2\,O = \underset{\text{(Parabanic Acid.)}}{C_6H_2N_2O_6} + 2\,CO_2$$

Parabanic acid passes into oxaluric acid through the addition of two equivalents of water:—

1 eq. parabanic acid $C_6H_2N_2O_6 + 2\,HO = 1$ eq. oxaluric acid $C_6H_4N_2O_8$; the oxaluric acid, again, when boiled in water, is finally decomposed into oxalic acid and urea:—

$$\begin{array}{llllll}
\text{1 eq. oxaluric acid } C_6H_4N_2O_8 & \text{1 eq. urea} & C_2 & H_4 & N_2 & O_2 \\
 & \text{2 eq. oxalic acid} & C_4 & & & O_6 \\
\cline{3-6}
 & & C_6 & H_4 & N_2 & O_8
\end{array}$$

On comparing these various formulæ together, we find that one equivalent of uric acid by the addition of four equivalents of water, and four equivalents of oxygen, are at last decomposed into two equivalents of urea, two equivalents of carbonic acid, and two equivalents of oxalic acid, passing through the intermediate forms of alloxan, parabanic acid, and oxaluric acid:

$$\begin{array}{lllll|lllll}
\text{1 eq. uric acid} & C_{10} & H_4 & N_4 & O_6 & \text{2 eq. urea} & C_4 & H_8 & N_4 & O_4 \\
\text{4 eq. water .} & & H_4 & & O_4 & \text{2 eq. oxalic acid} & C_4 & & & O_6 \\
\text{4 eq. oxygen} & & & & O_4 & \text{2 eq. carbonic acid} & C_2 & & & O_4 \\
\cline{2-5} \cline{7-10}
 & C_{10} & H_8 & N_4 & O_{14} & & C_{10} & H_8 & N_4 & O_{14}
\end{array}$$

If the oxalic acid be further oxidised by the addition of two equivalents of oxygen, there will remain as the final products of the decomposition of the uric acid: carbonic acid, and urea. The complete oxidation of the uric acid may be thus exemplified:—

$$\begin{array}{lr}
\text{1 eq. uric acid} & C_{10}\,H_4\,N_4\,O_6 \\
\text{4 eq. water} & H\quad O_4 \\
\text{6 eq. oxygen} & O_6 \\
\hline
 & C_{10}\,H_8\,N_4\,O_{16}
\end{array}
\qquad
\begin{array}{lr}
\text{2 eq. urea}\ \ .\ \ . & C_4\,H_8\,N_4\,O_4 \\
\text{6 eq. carbonic acid} & C_6\quad O_{12} \\
\hline
 & C_{10}\,H_8\,N_4\,O_{16}
\end{array}$$

It is evident from this, that the uric acid must, in the normal condition of things, undergo decomposition in the body; and we find that, by an excess of permanganate of potash, it is directly converted into carbonic acid and urea; and that when the oxidation is less complete, it passes into the form of allantoine, carbonic acid, oxalic acid, urea, and other products.*

5. By the action of reducing agents, such as sulphuretted hydrogen, hydrogen, &c., upon a solution of alloxan, crystals of a new compound, alloxantine, are precipitated ($C_8\,H_5\,N_2\,O_{10}$). Alloxantine is much less soluble than alloxan; it crystallises in oblique four-sided prisms, and becomes red under the action of ammoniacal vapour.

Alloxan and alloxantine are the source from whence murexide proceeds—the most important of the uric acid reactions. Thus, when a solution of alloxan and alloxantine are mixed with ammonia, it becomes of a purple-red colour, and after a time deposits crystals of murexide ($C_{16}\,H_8\,N_5\,O_{12} + N\,H_3$ purpurate of ammonia). Murexide crystallises in four-sided prisms, having a greenish cantharides-like reflexion; when pulverized it forms a brown powder, and dissolves in water with a deep purple colour. It serves on all occasions as a test for uric acid.

6. Uric acid, when treated with moderately dilute nitric acid, is dissolved, and alloxantine is then found in the solution. By carefully evaporating the solution almost to dryness, and by the further addition of nitric acid, alloxan will be formed out of the alloxantine. If the mixture be now acted upon by ammonia, the beautiful colour of murexide, which passes into a purple-blue on the addition of caustic potash, is obtained. By the aid of this test, the presence of the smallest quantity of uric acid may be recognised. If the residue is treated with potash or soda, instead of with ammonia, we obtain a beautiful purplish-violet solution, the colour of which becomes gradually paler when heated. Before the fluid is wholly evaporated, its beautiful colour is completely lost. (Distinction from Xanthine, p. 24.)

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* Annal. d. Chem. und Pharm. Bd. 99, p. 206.

7. Uric acid forms salts with different bases, all of which are more or less readily soluble in water, the most soluble being that of lithia. From these solutions the uric acid is precipitated in a crystalline form, on the addition of hydrochloric, acetic, and other acids. The precipitation takes place immediately in concentrated solutions; but in dilute solutions, as in the urine, it requires from twenty-four to thirty-six hours for its completion. The crystals are readily recognised under the microscope. A description of its different salts will be found under the head of *Sediments*.

8. An alkaline solution of uric acid immediately reduces nitrate of silver, even without heat. When paper, upon which a drop of nitrate of silver-solution has been let fall, is moistened with a solution of soda, in which only a trace of uric acid is dissolved, a dark-brown spot is immediately produced, though not more than $\frac{1}{1000}$ part of uric acid be present. A much less quantity, $\frac{1}{500,000}$ of a gramme, produces in the course of a few seconds a visible yellow reaction, and this, too, without the assistance of heat. (Schiff.)

9. A white precipitate of urate of the suboxide of copper is produced, when a solution of uric acid in potash is added to an alkaline solution of copper. On heating this precipitate to boiling with an excess of the copper-solution, the uric acid is oxidised, red suboxide of copper is separated, whilst the products of oxidation of the uric—viz., allantoine, urea, and oxalic acid remain in solution.

E. *Tests.*—I shall only treat here of the method of finding uric acid in the urine. There are two methods, either of which may be depended upon, by which uric acid may be separated from the urine and tested.

1. A small quantity of urine, say ten to fifteen grammes, is evaporated in a porcelain basin over a water-bath to a syrupy consistence—any albumen accidentally present in it having been previously removed by boiling, with the addition of a drop of acetic acid, and subsequent filtration. From the residue, the urea, together with the extractive matters and the salts soluble in alcohol, are removed by frequent washings with alcohol; the uric acid with the insoluble salts, and a little mucus being left. The salts are next extracted by the addition of a small quantity of dilute hydrochloric acid, so that at last the uric acid alone remains, mixed with a little mucus. For the more certain detection of uric acid, the following tests may be resorted to:—

a. A small portion of the uric acid is placed on a watch-glass with a few drops of nitric acid, and more or less perfectly dissolved by a gentle heat. The solution on being evaporated in a water-bath leaves a reddish residue. This residue when moistened with dilute ammonia (one in ten parts of water), instantly produces the purple-red colour of murexide, which passes into a beautiful violet, on the addition of a drop of caustic potash solution. When the quantity of uric acid is very small, the test will fail, should too much ammonia be employed; consequently, it is better to blow the vapour of ammonia off a glass rod dipped in a solution of ammonia on to the residue. By this means the test will show, with certainty, the presence of even mere traces of uric acid.

b. The residue is dissolved in a few drops of potash solution, which leaves the mucus undissolved; and from this solution of urate of potash the uric acid is separated in a crystalline form on the addition of hydrochloric acid, and may be recognised by its microscopic characters.

2. A larger quantity of urine (100 to 150 grammes), is mixed in a glass vessel, with 6 to 8 grammes of hydrochloric acid, and allowed to stand for twenty-four to forty-eight hours; at the end of this time the uric acid is separated in the form of coloured crystals, which partly float on the surface of the fluid, and are partly deposited on the sides and bottom of the glass. These crystals are readily recognised as uric acid, both by the aid of the microscope, and also by testing them, when removed by filtration, with nitric acid and ammonia.

3. If the quantity of the fluid to be tested for uric acid is small, 4 to 8 grammes of it are poured into a flat watch-glass, 6 to 12 drops of strong acetic acid added, and a few linen threads laid in it. The fluid is allowed to stand eighteen to twenty-four hours, in a temperature not exceeding 16° to 20° C. (61° to 68° Fahr.). At the end of this time, the uric acid is deposited on the threads in the form of crystals, which may be then examined microscopically. This process is of especial service in testing the serum of the blood of gouty subjects for uric acid. (*Dr. Garrod.*)

the hippuric acid, when taken internally, as was asserted by Kühne; it could not, in fact, be discovered either in the urine or in the fæces, and consequently appears to have undergone complete decomposition in the body. Verdeil and Dollfus found hippuric acid in the blood of oxen, as well as in their urine, and Hervier has also found it in diseased human blood.

Schlossberger has demonstrated the presence of hippuric acid in the scales of the skin in ichthyosis.

Hippuric acid is probably the product of the decomposition of the nitrogenous constituents of the body; for, as indeed may be gathered from its constitution (*Chemical Characters* 3 and 8), there are always indications of the presence of a benzoyl-compound in it; and Guckelberger has artificially prepared benzoic acid and benzonitrile, by the action of nitric acid on proteine-bodies. Why then may not the nitrogenous compounds undergo like decompositions within the body, and the products be afterwards separated with the urine, in the form of hippuric acid? Such an idea receives strong support from the well-conducted researches of Hallwachs. He did not, in fact, discover benzoic acid, or any benzoyl-compound in the ordinary food of the cow; so that the benzoyl-radical of hippuric acid could not possibly be derived directly from the food ingested. Hippuric acid is undoubtedly an excretion; but of its origin, we cannot speak with certainty.

B. *Microscopic characters.*—A boiling saturated solution of hippuric acid allowed to cool rapidly, when observed under the microscope, throws down a precipitate of fine needles and scales. But regular, well-formed crystals, are separated from a cold saturated solution on evaporation; these crystals are milk-white, semitransparent four-sided prisms and columns, terminating in two or four planes; their elementary form is invariably a right rhombic prism. (*Plate I. Fig.* 1.) A few of the crystals are occasionally seen to resemble the crystals of ammonio-phosphate of magnesia, from which, however, hippuric acid is readily distinguished by its chemical characters.

C. *Preparation.*—The fresh urine of the horse or cow (5 to 6 litres) is boiled for a few minutes with an excess of milk of lime, and filtered; the clear solution of hippurate of lime is then rapidly evaporated to one-eighth or one-tenth of its original volume, and treated with hydrochloric acid. In the course of twenty-four hours the hippuric acid is crystallised. It is then purified by a second admixture with milk of lime, and the filtered solution, after the addition of hydrochloric acid, left to crystallise. If the crystals are still impure, they may be once again dissolved in water, and mixed with well-burnt animal charcoal; and on the cooling of the solution, will be separated in long, colourless, semitransparent crystals. A second deposition of crystals may be obtained by evaporation of the mother-liquid.

Loewe treats fresh urine with sulphate of zinc, and evaporates it together with the resulting precipitate to one-sixth of its volume, filters it quickly, and separates the hippuric acid from the filtrate by means of hydrochloric acid. The hippuric acid must be purified by a second crystallisation. This method yields a very pure preparation.

Gössman gives us a good method for purifying coloured hippuric acid. The crystals are dissolved in a sufficiency of dilute soda-ley, and a solution of permanganate of potash then dropped into the solution, when heated to boiling, until, on testing a little of the filtered fluid, a pure white precipitate is obtained on the addition of hydrochloric acid. The whole filtrate is then treated while hot with a slight excess of hydrochloric acid, and allowed to crystallise.

D. *Chemical characters.*—Hippuric acid has a weak, bitterish taste, but no smell; 400 parts of cold water are required for its solution; but it is much more soluble in boiling water. Alcohol readily dissolves it; ether also dissolves it, but not so readily. Its solutions redden litmus strongly.

2. Hippuric acid heated in a test-tube, after the manner mentioned in speaking of urea, fuses into an oily liquid, which, on cooling, hardens into a milk-white crystalline mass. When strongly heated it decomposes, a sublimate of benzoic acid and of benzoate of ammonia being formed; at the same time a few red, oily drops appear, which have a peculiar smell like that of fresh hay, become solid on cooling, and are soluble in alcohol and ammonia, but not in water. Subjected to a stronger heat, it gives off an intense odour, like that of hydrocyanic acid, leaving a porous, coaly mass, which is perfectly combustible. By these peculiar characters, hippuric acid may be readily recognised and distinguished from uric acid and benzoic acid, with which last acid especially it has many points of resemblance. In the dry distillation, if the heat is not allowed to exceed 250° C. (482° Fahr.), the hippuric acid gives off benzoic

acid, slightly reddened by the presence of some foreign body, traces of hydrocyanic acid, and of a liquid compound, benzo-nitrile ($C_{14}\ H_5\ N$), having an odour very similar to that of bitter almonds.

3. Hippuric acid is unaltered by dilute mineral acids; but it is decomposed when heated with concentrated hydrochloric, sulphuric, or nitric acid. Crystals of benzoic acid are separated from the mixture as it cools; and a peculiar compound, glycocoll $C_4\ H_5\ N\ O_4$ (glycine or glycocine), having in its free state a slightly acid reaction, remains in solution, in union with the mineral acid:—

$$\underset{\text{(hippuric acid)}}{C_{18}\ H_9\ N\ O_6} + 2\ H\ O = \underset{\text{(benzoic acid)}}{C_{14}\ H_6\ O_4} + \underset{\text{(glycocine).}}{C_4\ H_5\ N\ O_4}$$

Glycocoll may be artificially prepared by the action of ammonia on chlo-racetic acid, so that it may be considered as an amide of acetic acid. $C_4\left\{\begin{matrix}H_3\\N\ H_2\end{matrix}\right.O_4$. Through the action of glycocol-oxide of zinc (amide of acetate of zinc) on chloro-benzoyl, Dessaignes, in fact, reproduced hippuric acid, this last being recognised in the form of benzoic acid, to which one atom of hydrogen is added, through the radicle of the amide of acetic acid, that is, of the glycocoll, $C_{14}\left\{\begin{matrix}H_5\\C_4\left\{\begin{matrix}H_2\ O_2\\N\ H_2\end{matrix}\right.\end{matrix}\right.O_4$.
Similar relations are presented to us by gallic acid.

4. Hippuric acid mixed with putrescent or fermenting matters is mostly converted into benzoic acid. This is the reason why experimenters often fail to find it in stale urine; the benzoic acid, thus formed, readily passing off with the watery vapour, whenever the urine is evaporated after the addition of a little hydrochloric acid.

5. When hippuric acid is dissolved in nitrous acid, or when nitric oxide is passed through a solution of it in nitric acid, a non-nitrogenous acid, benzo-glycollic acid ($C_{18}\ H_8\ O_8$) is formed, and nitrogen given off:—

$$(C_{18}\ H_9\ N\ O_6 + N\ O_3 = C_{18}\ H_8\ O_8 + 2\ N + H\ O).$$

A similar decomposition occurs, when hippuric acid is dissolved in an excess of dilute potash-ley, and chlorine passed through the cold solution as long as any nitrogen is given off.

6. Hippuric acid forms crystallisable salts with bases; and may be separated from their solutions (when concentrated) in the form of long needles, by the addition of hydrochloric acid.

7. The intensely bitter almond-like smell of nitro-benzine is produced when hippuric acid, subjected to the action of strong boiling nitric acid, is evaporated to dryness, and the residue heated in a glass-

tube. Benzoic acid gives a similar result. Cinnamic acid is distinguished by the characteristic odour of cinnamon. As mere traces of nitro-benzine yield a strong and somewhat lasting smell, this test may be used for ascertaining the presence of even very small quantities of hippuric acid. (Lücke.)

No reaction of this kind is given by albumen, gelatine, uric acid, sugar of urine, salicine, salicyluric acid, choloidinic acid, anisic acid, pyrogallic acid, picric acid, naphthaline, phthalic acid, indigo, and isatine.

E. *Tests.*—Hippuric acid can only be recognised in its pure form; for it is only then that it exhibits characteristic marks. Benzoic acid is the only body with which it can be confounded, and from this acid it may be readily distinguished by the following tests:—

1. Hippuric acid crystallises under the microscope in the forms above mentioned; benzoic acid, on the other hand, crystallises in scales, small columns, or six-sided needles, whose primary form is a right rhombic prism. (Funke, *Plate I. Fig.* 6.)

2. Dry hippuric acid, when heated, undergoes characteristic decompositions (see 2); but benzoic acid passes off undecomposed, in the form of a thick, white, pungent vapour.

3. Hippuric acid contains nitrogen; benzoic acid does not. In order to distinguish it, a small quantity of hippuric acid is heated with soda-lime—a mixture of caustic soda and caustic lime—in a narrow glass tube; thereupon, ammonia is soon given off, and may be recognised either by its smell, or by its property of blackening paper, moistened with a solution of subnitrate of mercury.

Uric acid is readily distinguished from hippuric acid by the form of its crystals, by its reactions with nitric acid and ammonia, as well as by its insolubility in alcohol and ether, in which hippuric acid is soluble.

Hippuric acid may be obtained from the urine by the two following methods; but the urine must, in both cases, be perfectly fresh. (See D. 4.)

1. From 800 to 1000 C. C. of urine are evaporated nearly to dryness in a water-bath, the residue triturated with powdered sulphate of baryta, acidulated with hydrochloric acid, and completely extracted with alcohol. After neutralising this alcoholic extract with soda-ley, the greater part of the alcohol is distilled off, and the remaining syrupy fluid, after the addition of oxalic acid, being kept stirred, is dried in a water-bath. The dried mass is next exhausted by a large quantity of ether, to which a little alcohol has been added, and the

ethereal solution evaporated by distillation almost to dryness. The crystalline residue is then heated with milk of lime, in order to remove the oxalic acid, filtered, the filtrate evaporated to a very small volume, and slightly acidulated with hydrochloric acid. Crystals of hippuric will now form in it in the course of a short time; and may then be tested chemically and microscopically. Exceedingly small quantities of hippuric acid may be distinguished by the nitrobenzine reaction. (See *Chemical characters*, 7.)

If the urine contains much hippuric acid, as it does after a dose of benzoic acid has been taken, crystals of hippuric acid may usually be obtained, by the simple addition of a little hydrochloric acid to the urine evaporated to the consistence of syrup. These crystals may be readily separated by alcohol from the uric acid, which is also thrown down.

2. The second method is Liebig's (*Annalen der Chemie u. Pharm.* 1844). The urine with a few drops of hydrochloric acid added to it, is evaporated to a syrup, and shaken with an equal volume of ether. If, as often happens, the ether, on separating, is not clear, one-twentieth of its volume of alcohol is added to the mixture, after it has stood for an hour. The layer of ether, containing the hippuric acid and some traces of urea, is removed with a pipette, and shaken up with small quantities of water; in this way the alcohol and urea are removed, the hippuric acid remaining in solution in the ether, from which it may be obtained by evaporation in a crystalline form. The crystals, if necessary, may be obtained perfectly colourless, by boiling with animal charcoal. In this operation, however, a considerable quantity of the hippuric acid is lost. Of these two methods of testing uric acid, I give a decided preference to the first.

SECTION VIII.

PHENYLIC ACID (*carbolic acid, or phenyl-alcohol*).

Composition:—

In 100 parts:	Carbon	76·93
	Hydrogen	6·40
	Oxygen	16·67
		100·00

Formula: $C_{12}H_{5}O, HO$.

A. *Occurrence.*—Phenylic acid was discovered by Wöhler in castoreum, and afterwards by Städeler (together with taurylic, damolic, and damaluric acids), as a constant constituent of the urine of cows, horses, and man. This acid has poisonous qualities, and is obtained from human urine in very small quantities only, so that it is at present doubtful whether it really exists ready-formed in the urine, or whether it is formed during the process required for its preparation. These acids, or the matters at least out of which they are formed, appear to be the cause of the odour of the urine. Städeler considers that they all pre-exist in the urine, and that they are, therefore, products of the metamorphic processes. Phenylic acid is also found in coal-tar; it is formed during the dry distillation of salicine with lime, as well as in the decomposition of many organic bodies at a red heat, &c. Schlieper obtained traces of it from the products of the oxidation of gelatine.

C. *Chemical characters.*—Anhydrous phenylic acid crystallises in long colourless needles, which melt at 35° C. (95° Fahr.), and boil at 188° C. (370° Fahr.). It has a smoky smell, is corrosive, and poisonous. It is scarcely soluble in water, but readily dissolves in alcohol and ether. Its solution coagulates albumen, and is strongly antiseptic.

1. The following compounds are formed by the action of nitric acid on phenylic acid: first of all nitro-, then dinitro-phenylic acid, and lastly, trinitro-phenylic acid ($C_{12} H_2 [3 N O_4] O + H O$), usually known by the name of 'picyric acid,' or 'Welter's bitter,' and which may be also formed by the action of nitric acid on indigo, salicine, &c.

2. Phenylic acid, acted on by chlorine, produces di- and trichlorophenylic acids, two and three equivalents of the hydrogen of the phenylic acid being replaced by the chlorine. ($C_{12} H_3 Cl O + H O$, and $C_{12} H_2 Cl_3 O + H O$.)

3. Per-salts of iron produce a violet-colour in a solution of phenylic acid, which takes a bluish shade, and, after a time, turns to a dirty-white cloudiness.

4. Nitrates of silver and mercury are reduced by phenylic acid.

5. A chip of deal, soaked in a watery solution of phenylic acid, and dipped in dilute hydrochloric acid, becomes of a deep-blue colour when exposed for a few moments to the sun's rays. The colour firmly resists the action of chlorine; under its influence the blue takes a lighter shade, but soon regains its depth, when the slip of wood is re-dipped in dilute hydrochloric acid.

6. Phenylic acid forms, with sulphuric acid, sulpho-phenic acid, which will remain fluid during months.

7. With caustic potash solution it hardens into a crystalline mass.

8. Benzonitrile, $C_{14} H_5 N$ see *Hippuric Acid*, which is one of the products of the decomposition of hippuric acid, may be regarded as a phenyl-cyanide $\left\{ \begin{matrix} C_{12} H_5 \\ C_2 N \end{matrix} \right.$: the phenyl group is, indeed, in all respects, very closely related to the benzoyl and salicyl compounds. Phenylic acid is also formed during the dry distillation of most of the salicylic salts, as well as of benzoate of copper—a fact worthy of note in reference to its formation in the urine.

Städeler has also discovered a series of other acids closely resembling phenylic acid. They are:—

1. *Taurylic acid*, $C_{14} H_8 O_2$ (?), which is isomeric with anisole. It is distinguished from phenylic acid by its higher boiling-point, and also by its forming a fixed compound with concentrated sulphuric acid, which separates at first as a fine white detritus, and then gradually accumulates into roundish masses.

2. *Damaluric acid*.—Composition:—

In 100 parts:	Carbon . . .	65·62
	Hydrogen . .	9·38
	Oxygen . . .	25·00
		100·00

Formula: $C_{14} H_{11} O_3 + HO$.

Damaluric acid is an oily fluid, having an odour of valerianic acid: it is heavier than, and slightly soluble in, water, and gives it a strongly acid reaction.

It forms very characteristic salts with bases. The baryta-salt crystallises in united tufted prisms, which are soluble in water, and form an alkaline solution. The salt is infusible, but after exposure to a red heat, yields carbonate of baryta in the form of the original salt; it contains 39·18 per cent. of baryta.

With silver it forms a white powder, which is not affected by the action of light; this salt contains 49·36 per cent. of oxide of silver.

Acetate of lead yields, with a solution of damaluric acid, a white precipitate, which appears under the microscope as fine prisms clustered together in roundish masses.

3. *Damolic acid* is the least known of these compounds. It is

oily, and heavier than water, and only slightly soluble in it. It forms with baryta a crystallisable and fusible salt, containing 27·50 per cent. of baryta. The damolic acid-salt crystallises the first out of a solution of damalurate and damolate of baryta.

Mode of obtaining and separating these four acids:—

1. The separation of them all together from the urine.

Fresh cow's urine (80 lbs.) is mixed with hydrate of lime, boiled, then decanted off from the superfluous lime, and evaporated to one-eighth of its original quantity; hydrochloric acid is added to the filtered solution, and after standing twenty-four hours, the mother-liquor is decanted from the precipitated hippuric acid and distilled. By repeated rectification of the milky fluid obtained by the first distillation, an oil-like, lightish-yellow liquid is obtained, the greatest part of which sinks to the bottom of the water which passed over with it. The presence of phenylic acid in this oil may be readily shown by its reaction with perchloride of iron, as well as by the blue colour it produces on a slip of fir-wood. The quantity of it in human urine is very small.*

2. Separation of the acids singly:—

The oil, together with the water obtained by the process just described, is mixed with an excess of hydrate of potash (the quantity used being weighed), and then subjected to distillation. A nitrogenous, powerfully smelling oil, whose nature has not been closely investigated, passes over with the distillate. As much sulphuric acid is added to the residue in the retort as is sufficient to neutralize five-sixths of the potash employed. The fluid resulting is then distilled, so long as a precipitate is formed in the distillate on the addition of acetate of lead. By repeated distillation of this product over common salt, the greater part of the acids are at last obtained in an oily form—a very small portion of them remaining in the watery solution, and giving it a strongly acid reaction. To separate these acid compounds, the distillate is saturated with carbonate of soda, and frequently shaken during the following twelve hours; the oily layer is then separated from the soda-salts by ether.

a. Acids, which are not retained by the carbonate of soda:—

From the ethereal solution obtained, as thus described (2.), the ether is removed by distillation, and the residue again mixed with strong potash-ley, and subjected to distillation. The potash-compound which remains behind is decomposed with bicarbonate of potash, and the product of the distillation entirely deprived of its water by chloride of calcium. By fractional distillation the greatest part passes over at 180° to 195° C. (354° to 383° Fahr.), and consists of phenylic and taurylic acids, which again by repeated fractional distillation can be partially separated. The acids differ chiefly in this, that taurylic acid boils at a higher temperature than phenylic acid; and that with concentrated sulphuric acid, taurylic acid forms a solid, and phenylic acid, a permanently fluid compound.

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* *Annal. der Chemie u. Pharm.*, vol., xcvii., p. 134.

b. Acids which are retained by the carbonate of soda:—

The solution of the salts of soda, which has been freed of its phenylic and taurylic acids by ether, is evaporated, decomposed by sulphuric acid, and distilled. The distillate, which has an odour of butyric acid and separates into an oily and a watery layer, is boiled with an excess of carbonate of baryta, and then left to crystallise. By fractional crystallisation various salts of baryta, containing different quantities of baryta (27 to 41 per cent.), are formed. The chief constituent is the acid, whose salt contains rather more than 39 per cent. of baryta (third, fourth, and fifth crystallisation). This acid is the damaluric acid $C_{14} H_{11} O_3 + H O$ (see *Damaluric acid*). The next acid, whose salt contains 27·4 per cent. of baryta (first and second crystallisation, is damolic acid. (See *Damolic acid.*)

The other baryta salts (in the evaporated mother-liquor) are a mixture of damaluric acid with another salt of baryta; but whether the acid in this salt is butyric, valerianic, or some new acid, has not yet been ascertained.

Human urine contains only a very small quantity of these acids. And if the urine employed in their preparation be not perfectly fresh, a certain amount of acetic acid is invariably produced.

SECTION IX.

URINE-PIGMENTS.

Composition unknown.

1. *Urohæmatine.*—It is probable that the normal colouring-matter of the urine, like bile-pigment, is a modification or product of the decomposition of the hæmatine, and is formed from it during the passage of the blood through the kidneys. Dr. G. Harley has of late carefully investigated this subject. He succeeded

in the preparation of a pure substance, which he satisfied himself, after careful investigation, was modified hæmatine of the blood,—an opinion which is confirmed by the discovery, that this substance always contains iron. Dr. Harley calls this body urohæmatine. The following is the method of its preparation:—A large quantity of urine is evaporated until the fluid has become of the colour and consistence of treacle; the pigment-matter is then extracted by alcohol, and, during its evaporation, the salts which crystallise are to be removed from time to time. The alcohol, deeply tinged, is heated to boiling, and, while boiling, treated with milk of lime, until the colour disappears. It is then filtered, and well washed with water and ether.

The compound of lime and colouring-matter, when dry, is treated with hydrochloric acid and alcohol, and filtered; the alcoholic solution is mixed with an equal quantity of ether, and being frequently shaken, left to stand for several days, in order that the ether may take up as much as possible of the colouring-matter. On the addition of water, the ether, charged with the colouring-matter, separates and is removed. The ethereal solution has a very beautiful, wine-red colour; but it is not yet perfectly pure, and must be washed with water to free it from any remaining trace of acids, and from salts and resinous matter. If this washing, however, is carried too far, a small quantity of the colouring-matter will be thrown down. The ethereal solution, thus purified, is then evaporated, and the pure colouring-matter left on the saucer as a dark-red, amorphous, resinous, substance, which becomes of a splendid red-colour when dissolved in alcohol and ether; and in many respects, especially in relation to acids and alkalies, closely resembles hæmatine. When this colouring-matter is burnt, a little residue remains, which consists solely of oxide of iron.

The pigment-matter thus obtained is insoluble in nitric, hydrochloric, and sulphuric acids, even in the strongest, and also in tartaric and oxalic acids. It is soluble in ammonia, hydrate of soda, and potash; insoluble in a solution of chloride of sodium, in chloride of barium and in water; but soluble in alcohol, ether, and chloroform, as is also blood-hæmatine in its pure state.

Scherer, in his experiments, prepared the colouring-matter of the urine by precipitating it with neutral and basic acetate of lead, and then treating the compound of pigment and lead-oxide with alcohol, mixed with hydrochloric acid. Dr. Harley succeeded in resolving the product thus obtained into four separate bodies, by treating it with ether, alcohol, and water mixed with hydrochloric acid. The residue of the ethereal extract, when evaporated nearly to dryness, [illegible] in which a dark-brown substance is found. This substance was recognised by Dr. Harley as an animal resin. The alcoholic extract is treated in a similar way. By evaporating the alcohol, and washing the residue with water and chloroform, the fat is removed, and the pigment-matter obtained pure. The mass which is insoluble in the alcohol, when treated with alcohol mixed with hydrochloric acid, is resolved into two other substances, whose nature has not been investigated by Dr. Harley. The first two kinds of pigment-matters, soluble in alcohol and ether, exhibit reactions so similar, when acted upon by tests, that they must, in the present state of science, be considered as one and the same. Hence, according to Dr. Harley's investigations, there are three kinds of pigment-matters. *Würzburger Verhandl.* Bd. 5. 1854. *Jour. f. Prakt. Chemie.* Bd. 64. p. 264.

2. *Uroxanthine* (Heller), *Indican* (Schunck).—Heller gives the name of uroxanthine to a substance, of which only a small quantity is present in healthy urine; but which, on the other hand, is often found in large quantities in diseased states of the urine. It gives the urine an intensely light-yellow colour, and has the peculiar character, when acted upon by acids, &c., of producing two new pigments, viz., uroglaucine and urrhodine, a saccharine substance being at the same time separated. According to the late investigations of Schunck, this body, which is found both in healthy and in abnormal urine, appears to have a similar constitution to indican obtained by him from the indigo-plant.

Indican is obtained from the indigo-plant in the form of a light brownish syrup, which is soluble in water, alcohol, and ether. This, the mother-substance of indigo-pigment, is readily decomposed when acted upon by sulphuric and hydrochloric acids, &c.; the colouring-matters, indigo-blue, indigo-red, &c., being separated, and a saccharine sort of substance, reducible by oxide of copper, indigo-glucine (C [illegible] H [illegible] O [illegible]), leucine, and volatile fatty acids (acetic acid, formic acid, &c.) remaining in solution. Indican is separated from its solution by an ammoniacal solution of acetate of lead. The substance obtained from the urine appears perfectly similar to this indican, and under the action of acids it likewise yields blue and red pigments, a sweetish body capable of reduction by oxide of copper being at the same time produced.

3. *Uroglaucine and Urrhodine.*—These substances are occasionally found in the sediment of abnormal urine. As before said, they are, according to Heller, products of the oxidation of uroxanthine. According to Schunck, they are very probably derivatives of indican.

a. Urrhodine—Indigo-red.—When the ethereal solution is evaporated, the colouring-matter is left in a solid form, and presents no appearance of crystallisation. It may, however, be obtained in an indistinctly crystalline form by the very slow evaporation of an alcoholic solution. The crystals of urrhodine are nearly black, and only present a carmine-red when in very thin layers. In an amorphous state, urrhodine forms rosy-red granules. It is insoluble in water, but soluble in cold alcohol and ether, to which it imparts a beautiful red colour. (Heller's *Archiv*, 1846. p. 21.)

b. Uroglaucine.—Uroglaucine presents itself in the form of a blue powder, which, under the microscope, is found to consist of fine-pointed needles; these needles are rarely single, but usually joined together in sets of two, three, or more. For the most part, they are grouped together in star- and sun-like shapes, which again unite together into larger masses, having a radiated form. Uroglaucine may be sublimed, and is reducible with sulphate of iron, &c. It is often found in the urine in degeneration of the kidneys, and, according to Virchow, sometimes in a crystalline form. The cyanurine of earlier observers is a mixture of the blue and red colouring-matter of the urine.

A. *Preparation* (after Schunck).—Urine is treated with acetate of lead as long as any precipitate is formed, and filtered; the filtrate is then precipitated with an excess of ammonia, whereby the indican (uroxanthine) is thrown down in combination with oxide of lead. The precipitate, collected and washed, is completely decomposed with cold dilute hydrochloric or sulphuric acid, and the solution filtered. If much of the indigo-forming substance is present, the filter and the precipitate will have already become of a bluish shade, and so also will the surface of the brown filtrate; but if only a small quantity is present, the blue pellicle will appear on the filter in the course of 24 to 48 hours, but never later. The brown filtrate deposits a dark brown powder, after the indigo-blue, which gradually separates by boiling, is removed. This powder has the same appearance as that which is obtained directly from the extractive-matter of the urine by boiling it with acids, and is partly

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soluble in soda-ley with a brown colour, and partly insoluble. The undissolved part is separated by boiling alcohol into two bodies, one of which is dissolved with a purple-blue colour, and appears to be identical with indigo-red, and the other has the properties of indigo-blue. (*Jour. für Prac. Chem.* Vol. 75, p. 378.)

B. *Preparation* (after Kletzinsky and Heller).—Urine, which has been turned to an indigo-blue colour by admixture with fuming hydrochloric acid, is thoroughly precipitated with acetate of lead, and the filtrate, freed from any excess of oxide of lead by sulphuretted hydrogen, is evaporated to one-third. The fluid, while warm, is poured into double or treble its volume of fuming hydrochloric acid, and allowed to stand for some days; during which time a thin, copper-red, variegated pellicle is formed on its surface, and the fluid gradually becomes turbid. It is next filtered, and the bluish-black mass which is separated thoroughly washed with water, and, after drying over sulphuric acid, treated with ether, which thereupon takes a darkish-red, or purplish hue, and contains a red amorphous, resinous-like mass, urrhodine (indigo-red, according to Schunck). The residue left by the ether is boiled with alcohol, and the deep corn-flower blue solution left at rest in a closed flask. In the course of a month a deep black velvety sediment is deposited, which frequently contains rudimentary crystals. (The elementary analysis of this precipitate agrees completely with that of indigo-blue, according to Kletzinsky.)

According to my own experience, urine rich in uroxanthine does not require this complicated process; for when mixed with an equal volume of hydrochloric acid, it very soon throws down the pigment. The quantity obtained is always very small, and not less than ten to twenty pounds of urine should be operated upon.

C. *Tests.*—The following very neat test of Heller may be employed for ascertaining the presence of even small quantities of uroxanthine in the urine. From 3 to 4 C. C. of strong fuming hydrochloric acid are mixed in a test tube with from twenty to forty drops of the urine to be tested. If uroxanthine is present the mixture assumes a reddish-violet or intense blue colour, in consequence of the decomposition of the uroxanthine. If the reaction be indistinct because of the small quantity of uroxanthine in the urine, it may be rendered much more marked by the addition of two or three drops of strong nitric acid; thereupon, in the course of a few minutes, but not immediately, a beautiful violet-colour is produced, which at first plays somewhat into a blue, but afterwards more into a red, and sooner or later assumes a dirty-red, and lastly, again becomes yellow. The coloration generally shows itself without the addition of the nitric acid; but with the aid of this acid the smallest traces of uroxanthine may be recognised. In this reaction, as in the others, the uroxanthine is resolved into urrhodine, uroglaucine, and sugar.

I have had an opportunity of observing for a lengthened period the presence of uroxanthine in the urine of a young man. He was about eighteen or twenty years of age, and apparently of sound constitution, and had secreted the pigment-matter at various times and for long periods together.

On the addition of an equal quantity of hydrochloric acid or nitric acid to this urine, it quickly became of a violet hue, gradually grew darker, and at last assumed a deep dark-blue colour. On shaking the mixture, and after it had been allowed to stand a short time, the colouring-matter separated in the form either of a deep-blue scum, or as a thin, shining, reddish-blue, glistening pellicle.

The colouring-matter, when washed, appeared as a deep-blue powder, with a reddish coppery grain; it was dissolved by boiling alcohol; but the greater part of it separated again as the alcohol cooled, the solution remaining of a violet or reddish colour. (Urrhodine.)

The product thus obtained sublimed at a moderate heat, forming a beautiful red vapour, which was deposited as a reddish-blue sublimate. This sublimate, under the microscope, presented the groups of needles above described. It could not be distinguished from sublimed indigo; and its conduct, when treated with concentrated sulphuric and nitric acids, and especially with reducing agents, such as protoxide of iron, and sulphide of ammonium, corresponded entirely with that of indigo.* Evaporation of the urine entirely destroyed the pigment, so that it could not be obtained from the residue. Nitrous acid also decomposed it.

I would call attention to a peculiar effect produced on this urine by concentrated sulphuric acid. When one-sixth to one-fourth of its volume of concentrated sulphuric acid was added, without shaking, to a small quantity of the urine, there appeared, first of all, at the point of contact of the two fluids, a reddish shade, which gradually became darker, and, spreading through the whole fluid, imparted to it a deep dark-red colour, passing into a purple-violet-red. This play of colours exactly resembles that which occurs when urine containing bile is treated with sugar and sulphuric acid; only, in the case referred to, the colours appeared without any addition of sugar. When the pigment was decomposed by evaporation the play of colours could not be obtained.

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* *Annalen der Chem. und Pharm.* Bd. 90, p. 120.

Carter availed himself of this reaction of uroxanthine, when brought under the action of concentrated sulphuric acid, as a test. For this purpose a test-tube is filled about one inch with the urine to be examined, and one-third of its volume of concentrated sulphuric acid (of 1·83 sp. gr.) carefully poured into the urine, down the side of the tube, which is then shaken. The mixture thereupon assumes more or less of a violet-blue, according to the amount of indigo-forming body which it contains. The process described must, however, be accurately carried out. If the sulphuric acid be of a different degree of concentration, or if it be added *guttatim*, &c., the test will either fail altogether or the result will be unsatisfactory. If the urine contains much urohæmatine, or bile-pigment, they must be previously separated by a little acetate of lead. If any sulphate of lead should be afterwards precipitated on the addition of sulphuric acid, the test is not interfered with, for the precipitate rapidly sinks, and does not interfere with the coloration of the fluid. On neutralising the sulphuric acid with ammonia, and shaking the mixture with one-third of its volume of ether, the fluid divides into three layers. The uppermost layer is of a ruby-red, and contains dissolved urrhodine: the middle one is blue, and contains indigo-blue (uroglaucine) in suspension; and the lowest, containing ordinary urine-pigment, is of a transparent yellow colour.

By this process, which is, however, far from perfect, Carter has shown the presence of indican in the blood.

Although indican is very frequently present in healthy urine, at least in small quantities, it is probable that in some diseases its quantity is so much increased as to render it a sign of disease, and consequently it is worthy the attention of physicians. At all events, indican (indigo-blue, &c.) becomes of much interest when regarded as a probable product of the decomposition of proteine-bodies—a view which is strongly supported by the nature of the products of the decomposition of indican, amongst which (as already mentioned) we find leucine and volatile fatty acids, together with a saccharine substance.

A comparatively large amount of indigo is obtained from the urine of the horse and the cow. Creosote and oil of bitter almonds, taken even in small quantities, increase considerably the quantity of indigo-blue in the urine. (*Kletzinsky.*)

We may readily conceive, that a vast number of different shades of colour, greenish, grass-green, blue, violet, red, may be imparted to the urine through the union of urohæmatine with varying quantities of urrhodine and uroglaucine.

4. *Uroerythrine.*—Uroërythrine is the pigment which gives to sediments of uric acid and urate of soda their brick, or rosy-red colour, the intensity of which increases on exposure to the air. It also appears in solution in abnormal urine, and gives to it its red colour. Nothing more, however, is known of this pigment. (Heller's *Archiv.* 1853, p. 391.)

In conclusion, I must speak of a substance which Scharling has discovered in the ethereal extract of urine. (*Annal. d. Chem. u. Pharm.* Bd. 42 p. 256.) He has not, however, yet succeeded in obtaining this substance, which he calls oxide of omichmyl, perfectly pure, nor has he closely investigated its nature.

Oxide of omichmyl has a resinous appearance, readily melts in boiling water into a yellow liquid, is soluble in alcohol, in ether, and in alkalies. It has an acid reaction; but it is not clear whether this peculiarity is proper to it, or depends upon the presence of some adherent acid. In its dry state it has the smell of castoreum, and in its moist a urinous odour; moistened with oil of turpentine, it emits a violet odour. Nothing certain is known of its chemical constitution; nor has its elementary analysis been yet made out.

SECTION X.

INORGANIC CONSTITUENTS OF THE URINE.

In addition to the organic substances already described, the healthy urine contains varying quantities of certain inorganic bodies, which remain as an ash when the urine has been evaporated, and the residue exposed to a very high temperature. We find, in fact, the whole of these bodies in the ash, with the exception of a little ammonia, which is driven off by the heat. During incineration these inorganic substances undergo new arrangements, being oxidised and reduced by the action of charcoal and the oxygen of the air. Hence they are found in the ash, in combinations different from those which they had when dissolved in the urine. If, however, the [illegible] appreciable quant [illegible] completely driven o [illegible] instance, after t [illegible] of the residu [illegible] the mass be strong [illegible] by the action [illegible] This fact suffices [illegible] the incineratio [illegible] in the Second Pa [illegible]

[illegible] potash, lime, a [illegible] potash) with uric a [illegible] phosphoric, and hydr [illegible] acid are also fou [illegible] when the urine [illegible] with the exception of [illegible] Sulphuretted hydrogen som [illegible] The quantity of i [illegible] persons, and und [illegible] of the body. In men it may va between 9·06 and 24·50 grammes, and in women between 10· and 19·63 grammes. Lehmann, when living on a mixed diet, fou in his urine 15·245 grammes daily, the quantity varying betwe 9·652 and 17·254 grammes.

We shall next describe the different salts found in the urine.

SECTION XI.

Chloride of Sodium.

[illegible] Nearly the whole of the chlorine found in t urine is combined with sodium. The quantity of chloride of sodiu which is separated with the urine varies in different persons, and different periods of the day. Hegar, in his inaugural thesis, h given us the results of observations respecting these variations, ma on eight persons. They are, shortly, as follows:—The avera quantity of chlorine passed in twenty-four hours was 10·46 gramme which corresponds with [illegible] grammes of chloride of sodium. T quantity of chloride of sodium in the urine was most abundant aft midday;—during the night the quantity diminished considerably, but it increased again in the morning. Bodily exercise increases, and slight deviations from health readily lessen its secretion. The quantity of chlorine, again, is much diminished after beer-drinking. As regards the total amount of chloride of sodium secreted during twenty-four hours, the latest observations of Bischoff differ somewhat from those of Hegar's. (Bischoff, *Der Harnstoff*. 1853. p. 23.) Bischoff found that in his own urine the quantity varied between 8·64 and 24·84 grammes in the twenty-four hours, the average being 14·73.

The quantity of chloride of sodium in the urine is remarkably diminished in many diseases, and, indeed, in all diseases in which a large amount of exudation has taken place. Redtenbacher found that the quantity of chlorides was often reduced to a minimum in pneumonia, so that, in some cases, no precipitation whatever occurred on the addition of a salt of silver to the urine.

B. *Microscopical characters.*—Chloride of sodium, observed under the microscope, crystallises in beautiful, well-formed, regular pyramidal cubes. It undergoes, however, a distinct modification when separated from a solution containing urea;—in such case, the ordinary cubes are replaced by octohedral and tetrahedral forms. This peculiar character of chloride of sodium has been turned to account in determining the presence of small quantities of urea in animal fluids. It has, however, been found, that even pure chloride of sodium, especially when separated in the form of very small crystals, assumes varied combinations of its regular forms of crystallisation, and that it has a particular tendency to do so when the solution contains any organic matter. This method, therefore, of testing the presence of urea has been abandoned.

C. *Chemical characters.*—1. Chloride of sodium readily dissolves in water, and imparts to the solution a very saline taste. When water is added to pure, roughly-broken, crystallised rock-salt, at a temperature of 12° to 24° C. (54° to 76° Fahr.), and the mixture shaken from time to time during 24 hours, it is found that it invariably takes up the same quantity of salt. In 10 C. C. of this solution, when filtered and clear, Liebig and others found, as an average of several closely-agreeing observations, 3·184 grammes of chloride of sodium. Of this fact we make constant use in quantitative analysis.

2. Nitrate of silver occasions a white curdy precipitate in all fluids which contain chloride of sodium, the precipitate being

insoluble in nitric and hydrochloric acids. When, however, a solution of nitrate of silver is added to urine which has been acidulated with nitric acid, the pigments of the urine are also thrown down by the nitrate of silver, and, consequently, the precipitate is not pure chloride of silver. This fact is worthy of note in reference to the quantitative analysis of the chlorine of the urine by the aid of nitrate of silver.

3. Sub-nitrate of mercury, added to chloride of sodium, immediately throws down a precipitate of subchloride of mercury, which is almost wholly insoluble in acids.

4. When a concentrated solution of chloride of sodium is mixed with an equally concentrated solution of protonitrate of mercury, both salts are decomposed; nitrate of soda is formed, and the fluid solidifies into a thickish crystalline mass of corrosive sublimate. The same decomposition also takes place in weak solutions of these salts; but in such cases the corrosive sublimate remains in solution. We found, under the head of Urea, that when nitrate of mercury is added to a solution of urea a precipitate of oxide of mercury and urea is thrown down. Protochloride of mercury, on the other hand, throws down no precipitate, either in neutral or acid solutions of urea.

The following method, adopted by Liebig in carrying out the quantitative analysis of chloride of sodium in the urine, will now be easily understood:—The phosphoric and sulphuric acids are in the first place separated from the urine by the addition of nitrate and of caustic baryta; the alkaline filtrate is then rendered neutral or slightly acid by nitric acid; so that the fluid consists of a weak acid solution of chloride of sodium and urea. A solution of dilute protonitrate of mercury is now dropped into it, and where the fluids come into contact a white precipitate is observed, which disappears when shaken. This precipitate is a combination of urea and protoxide of mercury. As, however, chloride of sodium is present in the solution, the nitrate of mercury is immediately converted into corrosive sublimate, which does not throw down urea in a weak acid solution. The precipitate consequently disappears, and leaves the solution as clear as it was originally. This proceeding is again and again repeated, nitrate of mercury being gradually dropped into the solution, until the whole of the chloride of sodium in it is exhausted by the union of its chlorine with the mercury. At this point, on the further addition of the protonitrate of mercury, as there is no longer any chloride of sodium to change the nitrate into a chloride, we obtain a permanent precipitate of urea and oxide of mercury.

If, therefore, we know the exact quantity of nitrate of mercury which has been used, we can readily calculate the quantity of chloride of sodium in the urine, one equivalent of oxide of mercury corresponding with exactly one equivalent of chloride of sodium.

5. When a few drops of a solution of neutral chromate of potash are added to a neutral solution of chloride of sodium, containing phosphate of soda, and a solution of nitrate of silver then dropped through a pipette into the mixture, the whole of the chlorine is, in the first instance, thrown down in the form of chloride of silver. But, if more of the solution of silver be now dropped into the mixture, chromate of silver is formed, and imparts to it a permanent red colour. Up to this stage of the process, the phosphoric acid remains completely dissolved, the salt of silver precipitating these three acids in the following order:—Chlorine, chromic acid, and phosphoric acid. (Mohr's volumetrical method.)

D. *Tests.*—The reaction described with nitrate of silver, always serves as a test for the presence of chloride of sodium in the urine. The phosphoric acid in the urine, it is true, also throws down a precipitate with nitrate of silver; but this precipitate—phosphate of silver—is soluble in nitric acid, which the chloride of silver is not. Consequently in testing the urine for chlorine we must, either before or after the nitrate of silver is dropped into it, render the mixture strongly acid by the addition of nitric acid. In the first case, the phosphate of silver will not be thrown down; and in the second, it will be immediately dissolved, the chloride of silver alone remaining, in the form of a cheesy flocculent precipitate.

In urine which has been evaporated to a syrupy consistence, chloride of sodium crystallises, after a short time, in cubes or octohedra, which are readily recognised. The presence of the soda may be shown by the peculiar character of salts of soda, viz., that when heated to redness on platinum wire in the inner blowpipe-flame, they produce an intensely yellow colour.

SECTION XII.

Chloride of Potassium.

Urine contains chloride of potassium as well as chloride of sodium; and the two salts have exactly similar crystalline forms. The presence of potash in the urine is tested in the following way:—A little hydrochloric acid is first added to it, and then an equal volume of a mixture of alcohol and ether, and, lastly, a solution of chloride of platinum. In the course of a few hours, beautiful octohedra of the double chloride of potassium and platinum, mingled with ammonio-chloride of platinum, are deposited from the mixture, and may be readily recognised under the microscope.

SECTION XIII.

SULPHATES.

A. *Occurrence.*—Numerous researches concerning the quantity of sulphates in the urine have been recently made under Vogel's directions. From these it appears that the average quantity of sulphuric acid passed with the urine, by an adult, is 2·094 grammes in twenty-four hours. The quantity increases during digestion, is somewhat less during the night, and falls to its minimum in the forenoon. The amount of sulphates is increased for a time by large draughts of water, but is afterwards proportionally diminished. (Gruner.) Sulphates taken by the mouth are wholly discharged with the urine in the course of the following eighteen to twenty-four hours. The ingestion of pure sulphur increases the sulphur-constituents of the urine. There is no doubt that the sulphur, which is introduced into the body with the proteine substances of the food, is gradually oxidised and converted into sulphuric acid, which, again, united with alkalies, is afterwards discharged with the urine. Consequently, a rich animal diet increases the sulphuric acid as well as the urea in the urine. Diseases have a marked influence over the excretion of sulphates, sometimes increasing and sometimes diminishing the quantity of them in the urine.

B. *Chemical characters.*—Some of the sulphates are soluble, and some of them insoluble, in water. The insoluble salts are mostly white, and the soluble colourless in their crystalline state. The sulphates of the alkalies and alkaline earths are not decomposed at a high temperature; but if heated with charcoal, or with organic matters which yield charcoal, they are reduced to the state of sulphurets, and their presence may be then recognised by the odour of sulphuretted hydrogen, which they give off when the heated mass is moistened with a little acid. When this test is tried on clean silver, a black spot is left on it.

1. Chloride of barium, added to solutions of the sulphates, occasions a white, pulverulent precipitate of sulphate of baryta, which is insoluble in hydrochloric and nitric acids.

2. Acetate of lead throws down sulphate of lead.

3. Sulphuretted hydrogen may be produced when organic matters, mixed with sulphates, are exposed in a moist state to a moderately warm temperature. It is possible, therefore, that the sulphuretted hydrogen which is occasionally met with in the urine may be formed in a similar way.

C. *Tests.*—The sulphates yield, with salts of baryta, a precipitate which is insoluble in acids, and recognisable even when the solution is exceedingly diluted. Consequently, in testing the urine for its sulphates, we first of all render it strongly acid by the addition of nitric acid or hydrochloric acid, for the same reasons as given in the case of chloride of sodium, and then add to it a solution of chloride of barium or nitrate of baryta. The precipitate which results—sulphate of baryta—is a sure indication of the presence of sulphuric acid. If, therefore, we take a certain volume of urine, say 10 C. C., and add to it an equal or sufficient quantity of chloride of barium and hydrochloric acid, we obtain, from the greater or less quantity of precipitate which is thereby thrown down, an approximative estimate of the amount of sulphates present in it.

SECTION XIV.

Acid Phosphate of Soda.

A. *Occurrence.*—According to Liebig, this salt is undoubtedly present in the urine, and is, moreover, in most cases, the chief cause of its acid reaction. With regard to the amount of phosphoric acid in the urine, numerous calculations have been made, especially by Breed. (*Annal. der Chem. u. Pharm.* Bd. 78, p. 150.) From 3·765 grammes to 5·180 grammes was the average quantity of phosphoric acid passed during twenty-four hours by several persons.

It appears to me, however, from numerous experiments, which have been lately made, that this quantity of phosphoric acid is somewhat too high for the 24 hours—a fact which may be readily explained by the defective method of analysis (with perchloride of iron) hitherto employed. I have not found more than 2 grammes of phosphoric acid in healthy urine during the twenty-four hours, since I have employed the volumetrical method with a solution of a sesqui-salt of uranium for determining the quantity of phosphoric acid. A new series of experiments, made under normal conditions with this very sensitive method of analysis, is much needed.

Phosphoric acid was found to be somewhat augmented by increase of drink; but, according to Winter, this happened only during the first two or three hours after drinking. Winter also found that the quantity of phosphoric acid in the urine was considerably greater during the night than in the morning, and that it was greatest in the afternoon; for as Winter and Breed both observed, the taking of food increased very greatly the quantity of phosphoric acid. In diseased states of the body the variations are considerable, as we may readily imagine; according to Heller, they vary in much the same way as the sulphates do.

B. *Chemical characters.*—1. The acid phosphate of soda dissolves readily in water, and imparts to it an acid reaction. It is not altered when exposed to a red heat; but if previously well-mixed with charcoal or any organic matters, and then heated, part of its phosphoric acid is decomposed, and phosphorus, which immediately passes off in vapour, is formed.

2. Chloride of barium and nitrate of baryta, added to the solution of phosphate of soda, throw down a precipitate of phosphate of baryta, which is readily dissolved in acids.

3. Phosphoric acid forms, with lime and magnesia, compounds insoluble in water, but which dissolve, even in acetic acid, without decomposition. The phosphate of lime and the phosphate of magnesia, which we meet with in the urine, are held in solution by the free acid, or the acid salts of the urine. When the urine is neutralised by ammonia, the phosphate of lime is thrown down unchanged, but the phosphate of magnesia unites with ammonia, and forms a precipitate of ammonio-phosphate of magnesia. It is in this way that the ammonio-phosphate which appears as a sediment in alkaline urine is formed. The alkaline reaction of urine usually depends upon the presence of carbonate of ammonia, which is produced by the decomposition of the urea; but whenever this decomposition takes place, the free acid of the urine disappears,

and the earthy phosphates no longer remain in solution. The phosphate of lime, under such circumstances, separates in an amorphous form, and the phosphate of magnesia in beautiful crystals of the ammonio-phosphate of magnesia.

4. Perchloride of iron, added to a solution of the phosphates, which has been rendered acid by free acetic acid, throws down a yellowish-white gelatinous precipitate of perphosphate of iron. This compound is soluble in all acids, except acetic acid; consequently, when we desire to precipitate the phosphoric acid out of any solution by perchloride of iron, we must take care that it does not contain any free acid except acetic acid. Should any other free acid be present, acetate of soda and free acetic acid must be added to the solution before the precipitation by perchloride of iron is effected; by this means the solution is converted into an acetic acid solution, in which the phosphate of iron is insoluble. This reaction is made use of, after Liebig's method, in the volumetrical analysis of phosphoric acid.

5. A solution of phosphate of soda, mixed with a solution of protonitrate of mercury, immediately produces a copious white precipitate of phosphate of mercury, which soon crystallises when it is left at rest. Corrosive sublimate, on the other hand, when mixed with phosphate of soda, does not occasion any cloudiness in the solution. Consequently, if a solution of chloride of sodium is added to a mixture of phosphate of soda and nitrate of mercury before the precipitate crystallises, an interchange takes place between the phosphate of mercury and the chloride of sodium, — corrosive sublimate and phosphate of soda being formed. Corrosive sublimate, however, does not decompose phosphate of soda, and the fluid therefore remains bright and clear, in consequence of the disappearance of the precipitate which was at first formed.

Liebig has grounded upon this fact a plan for ascertaining with tolerable accuracy the quantity of oxide of mercury in a solution of nitric acid. One equivalent of phosphate of mercury requires for its decomposition exactly one equivalent of chloride of sodium; if, therefore, we know the quantity of chloride of sodium which is employed, we also know the quantity of mercury in the solution tested.

We make use of this method in the preparation of standard solutions of mercury for the determination of chloride of sodium and urea, after Liebig's method.

6. When a hot solution of a phosphatic salt, which is soluble in

water or acetic acid, is treated with sesquiacetate or nitrate of uranium, a yellow precipitate of phosphate of uranium is immediately produced. And if an ammoniacal salt, in sufficient quantity, be present, the precipitate will also contain ammonia ($2\,(Ur_2\,O_3)\ NH_4\,O,\ PO_5 + X\ HO$); but it yields, like the former, when heated to redness, pyrophosphate of the sesquioxide of uranium, $2\,(Ur_2\,O_3)\,PO_5$. The precipitate is not soluble either in water or acetic acid, but dissolves readily in mineral acids; when, however, an excess of an acetate is added to the latter the whole of the precipitate is again thrown down. We now make use of this test in the volumetrical analysis of phosphoric acid.

D. *Tests.*—(See Section XV.)

SECTION XV.

PHOSPHATES OF LIME AND MAGNESIA.

Both of these earthy phosphates, as already stated, are present in a state of solution in acid urine; they are, however, precipitated whenever the urine is rendered alkaline.

We obtain a tolerably accurate idea of the quantity of earthy phosphates in the urine by invariably employing the same volume of urine, 10 C. C., for example, and observing the quantity of precipitate which is thrown down on the addition of an alkali. I shall, in the Third Section, call attention to the experience of Beneke on this subject.

The quantity of earthy phosphates varies considerably both in the urine of health and disease; on this point Beneke has made a great number of observations. (See Beneke, *Der Phosphorsaure und oxalsaure Kalk.* Göttingen, 1850.) Lehmann found that under a mixed diet the average quantity of earthy phosphates discharged with the urine in twenty-four hours was 1·093 gramme; Lecanu, on the other hand, makes the quantity vary, during the twenty-four hours, from 0·029 to 1·960 gramme. The amount of phosphates in the urine seems to bear a very close relation to the nature and quantity of the food which is taken; it is, for instance, much greater under a purely animal than under a vegetable diet. Lehmann, in the twelve days during which he lived solely upon animal food, passed an average of 3·562 per cent. of phosphates in twenty-four hours. The quantity of the phosphate of lime is often considerably diminished in the urine of young children and of women in the puerperal state. In the latter, indeed, and particularly in the sixth to eighth month of pregnancy, it often happens, that the urine contains no lime.

An extended series of observations, which I made in the case of four healthy young men, concerning the separation of the earthy phosphates, gave the following results:—

1. From 0·9441 to 1·012 gramme was the average amount (in fifty-two observations) of earthy phosphates passed during twenty-four hours by adult men of twenty to twenty-five years of age, under normal conditions.

The maximum reached an average of 1·138 to 1·263; once only was 1·554 gramme passed in the twenty-four hours.

The average minimum was 0·8; on one occasion the minimum was only 0·328 gramme.

2. The average quantity of phosphate of lime found, in fifty-two observations, was 0·31 to 0·37 gramme. The maximum (mean) quantity was between 0·39 to 0·52; it once reached to 0·616 gramme.

The minimum was tolerably constant 0·25; once only was it 0·15 gramme.

3. The average amount of phosphate of magnesia in fifty-two observations was 0·64 gramme. The average maximum quantity was 0·77; once only it reached to 0·938. The mean of the minimum quantity was 0·5; the minimum in one case was as low as 0·178 gramme.

4. Under normal conditions of the body, an average of about 3 eq. of $2\,MgO, PO_5$ was passed with the urine for each equivalent of $3\,CaO, PO_5$. 100 parts of the phosphates contained an average of about 67 per cent. of phosphate of magnesia, and 33 per cent. of phosphate of lime.

5. Salts of lime, taken by the mouth, either do not pass away at all with the urine, or only in very small quantities; the amount therefore, of the normally secreted phosphates is not appreciably increased by their ingestion.

6. In diseases, the absolute quantity of earthy phosphates differs considerably from the normal standard, and so also does the relative proportion between the phosphates of lime and magnesia.

Tests.—There is no difficulty in ascertaining the presence of phosphoric acid in acid urine. The precipitate of earthy phosphates, which is immediately thrown down on the addition of ammonia, is a sure test of its presence. We can also readily discover whether o not the urine contains other phosphates, besides the precipitate phosphates of lime and magnesia, by filtering the precipitate whic is thrown down by the ammonia, and testing the filtrate, after it ha been made acid by acetic acid, with a small quantity of perchlorid of iron; if a whitish-yellow precipitate be thereby thrown down, th presence of some other phosphate in the urine is indicated. Th earthy phosphates are found in the form of sediment in alkalin urine, and will be therefore spoken of under the head of *Sediment* In order to separate the lime from the magnesia in the precipitat which is thrown down by ammonia, and which consists of phosphat of lime and ammonio-phosphate of magnesia and the precipitate i dissolved in acetic acid, a little chloride of ammonium added, an then a solution of oxalate of ammonia, which precipitates the lim in the form of an oxalate; the magnesia remains in solution, an may be afterwards precipitated from the filtrate by ammonia in th form of ammonio-phosphate of magnesia.

SECTION XVI.

IRON.

A. *Occurrence.*—Iron is rarely found, except in the ash of urin and then only in exceedingly small quantity. According to D Harley, it is a constant constituent of urohæmatine, which leaves a ash of nearly pure oxide of iron when strongly heated. Iron ma be readily obtained from the ash of urine which contains blood; an this fact was been made use of as being demonstrative of the existence of blood in the urine, when its presence could not be show microscopically—there being no corpuscles visible in it. This tes is, however, a very unsafe one in several respects, for, when preparations of iron have been taken by the mouth, the urine often contain a quantity sufficient to make its presence immediately recognisabl by ordinary reagents; and then, again, in other cases, iron is foun only in very small quantity in the ash.

B. *Chemical characters.*—Sulphide of ammonium, added t solutions of protoxide and peroxide of iron, throws down a blac precipitate of sulphuret of iron, which is readily soluble in hydrochloric and nitric acids.

2. Ferrocyanide of potassium, added to a solution of peroxide of iron, occasions a deep-blue precipitate of ferrocyanide of iron (Prussian blue) $Cfy\ 3 + 4\ Fe$. The precipitate which it forms in solutions of protoxide of iron is of a bluish-white colour, and consists of ferrocyanide of potassium and iron ($K, Fe\ 3, Cfy\ 2$).

3. Sulphocyanide of potassium does not affect solutions of the protoxide of iron, but it produces an intensely red colour of sulphocyanide of iron in solutions of the per-salts.

4. If a solution of permanganate of potash is added to an acid solution of a salt of the protoxide of iron, the protoxide passes wholly into a state of peroxide; and when this stage of the process is attained, a few drops more of the solution of permanganate of potash, added to the mixture, impart to it a beautiful red colour, $10\ (Fe\,O, S\,O_3) + 8\ S\,O_3 + K\,O, Mn_2\,O_7 = 5\ (Fe_2\,O_3, 3\ S\,O_3) + K\,O, S\,O_3 + 2\ (Mn\,O, S\,O_3)$.

c. *Tests.*—For testing and ascertaining the presence of iron in the urine, the ash obtained from the urine is always employed. The ash is dissolved in a little hydrochloric acid, and the solution divided into two portions. One portion is boiled with a drop of nitric acid, and sulphocyanide of potassium then added to it; thereupon, if only the smallest quantity of iron be present, the fluid will assume a reddish colour, and if a considerable quantity of it, a deep dark-red colour. When mere traces of iron are present, the change of colour is best observed by placing the tube over a white ground and inspecting it from above. If, instead of sulphocyanide of potassium, we add to the second portion of the fluid—after boiling it with nitric acid and diluting it—ferrocyanide of potassium, we shall find that in a short time blue flocculi of Prussian blue separate in it; and if the quantity iron be considerable, the Prussian blue will be immediately thrown down of a beautiful colour.

SECTION XVII.

Ammoniacal Salts.

The determination of the presence of ammoniacal salts in normal urine is attended with much difficulty. We well know how readily the colouring and extractive matters of the urine undergo decomposition, and how easily the urea passes into carbonate of ammonia, especially [illegible] the other matters mentioned above) are also present in it. [illegible] the reason why opinions differ so much concerning [illegible] and the quantity of ammonia present in healthy urine. Ammonia is always found in the products of the distillation of [illegible] which has an acid reaction, however low the temperature at which the distillation is effected; and yet the remaining [illegible] urine is often found to redden litmus, even more [illegible] at first. Thus apparently contradictory pheno[illegible] explained:—The acid phosphate of soda of the [illegible] causes decomposition of the urea, in consequence [illegible] ammonio-phosphate of soda is formed. Now this salt has [illegible] at 100° C. (212° Fahr.), of giving off [illegible] again to the state of acid phosphate of soda. [illegible] as the distillation continues, the acid phos[illegible] upon the urea: and the urine therefore [illegible] its acid reaction, whilst a considerable quantity [illegible] in the distillate.

W[illegible] however, the presence of small quantities of ammoniacal [illegible] urine may be ascertained with certainty; [illegible] of Boussingault, and of myself, leave [illegible].

[illegible] ammoniacal salts in acid urine, freshly [illegible] is precipitated by a solution of sugar of lead, [illegible] and the filtrate treated cold in a [illegible] The flask is then closed with a stopper, [illegible] turmeric-paper is attached. This test-[illegible] Whence comes the ammonia thus [illegible] of lime? Urea is not decomposed [illegible] are the pigment and extractive mat-[illegible] *we must consider it as* [illegible] *contains ammoniacal* [illegible] *normal urine (precipi-*[illegible] *which is capable of* [illegible] *by milk of lime, in* [illegible] I made use, in my experi-[illegible] This process is founded on the fact, that an aqueous solution of ammonia allows the ammonia to pass off in vapour, at an ordinary temperature, and in a comparatively short space of time, when exposed in thin layers to the action of the air in a shallow vessel. The ammonia which thus passes off may be fixed by a standard solution of sulphuric acid, and its quantity determined.

Having satisfied myself of the practicability and correctness of this method, I proceeded to ascertain the quantity of ammonia passed by healthy men in 24 hours. My experiments show that an average of 0·7243 gramme of ammonia, corresponding with 2·2783 grammes of sal-ammoniac, was secreted by men of from twenty to thirty-six years of age during 24 hours. The quantity varied in 24 experiments between 0·3125 and 1·2096 gramme of ammonia, corresponding with 1·4272 and 3·8038 grammes of sal-ammoniac. I made my experiments on two healthy men of twenty and thirty-six years of age, and found that the latter passed on an average the largest quantity of ammonia in the 24 hours.

The following Table will show the difference:—

	Man 20 years old.		Man 36 years old.		Difference.	
	NH_3	NH_4Cl.	NH_3	NH_4Cl.	NH_3	NH_4Cl.
In 24 hours .	0·6137,	1·9305	0·8351,	2·6361	0·2214,	0·7056
In 1000 C.C. of urine . .	0·3939,	1·2390	0·5245,	1·6560,	0·1306,	0·4170

The greatest part of the sal-ammoniac taken by the mouth passes away unchanged with the urine.

SECTION XVIII.

Silicic Acid.

Urine contains only a very small quantity of silicic acid. The following is the process for obtaining it:—A largish quantity of urine is evaporated in a platinum or silver basin, and the residue reduced to an ash. The ash is mixed with an excess of pure carbonate of soda and potash, and fused for some time in a platinum crucible. The mass is then dissolved in water, the mixture acidified with hydrochloric acid, and evaporated to dryness in a platinum dish in a water-bath. The residue is washed with water, and the silicic acid remains behind in a pure state.

The silicic acid thus obtained is a white powder, without taste or smell, and feels gritty between the teeth. It is insoluble in water and in acids, but is completely dissolved, leaving no residue, when boiled in a solution of carbonate of soda. (Signs of purity.)

ABNORMAL CONSTITUENTS OF THE URINE.

SECTION XIX.

ALBUMEN.

Composition :—		Scherer.	Mulder.
In 100 parts :	Carbon . .	54·883	53·5
	Hydrogen . .	7·035	7·0
	Nitrogen . .	15·675	15·5
	Oxygen .	22·365	22·0
	Sulphur .		1·6
	Phosphorus		0·4
			100·0

Its rational formula is not known.

A. *Occurrence.*—Albumen is the most important of the different materials required for the maintenance of the body; its serves for its nourishment, as well as for the restoration of the used-up tissues. It is therefore present in large quantities in all parts of the body, and forms the chief constituent of the blood, the lymph, and the chyle, of all serous fluids, and of the liquid of cellular tissues. Pathologically, albumen is found in the urine, under very various conditions —in slight, as well as in the most serious disorders of the body. In a perfectly healthy state of the body no albumen passes away with the urine. Observation teaches us, that its presence in the urine is not invariably a consequence of kidney-disease, for there are periods in the course of many chronic and acute diseases, during which albumen appears in the urine. Its occurrence is most constant in those affections of the kidneys to which the name of "Bright's disease" has been given.

It is not the object of this book, nor is it my intention to give an account of the different diseases in connexion with which albumen is found in the urine. This much, however, is certain, that it is necessary to test for albumen every specimen of pathological urine, the condition of which we wish to investigate; for, as we have seen, the presence of albumen in the urine is not associated with any one particular form of disease.

The presence of albumen in the urine is not indicated by any special microscopic characters.

B. *Chemical characters.*—Albumen belongs to the class of nitrogenous principles of animal and vegetable bodies, which Mulder has associated under the head of "proteine-bodies." All these compounds—albumen, caseine, fibrine, syntonine, &c.—are closely allied in their percentage composition, and have a great resemblance in their chemical characters, but differ in their actual constitution. The chief representative of this class is albumen, whose importance in the animal economy is great.

Albumen presents itself to us under various modified forms. Two of its conditions, the soluble and the insoluble, require especial notice. We find it in a soluble state in all parts of the body. Its solution does not depend solely upon the presence of water, but is in part attributable to the presence of saline matters, and more especially of a free alkali. When a solution of pure albumen is evaporated *in vacuo*, or at a temperature of 50° C. (122° Fahr.), the dissolved albumen is left as a pale-yellow, translucent mass, which may be easily reduced to a white powder. It swells in water to a gelatinous mass, and is only partially soluble in it; when, however, a small quantity of any alkaline salt is added, its complete solution rapidly takes place. The plane of polarisation is turned to the left by a solution of albumen.

The influence of numerous bodies, and sometimes, indeed, the action of the air alone, converts the soluble into the insoluble form of albumen. Recently-formed insoluble albumen has a whitish flocculent appearance, is without taste or smell, and, under the microscope, shows as an amorphous granular coagulum. When dry, it forms a yellow, horny, translucent mass, which is easily pulverised, and is insoluble in water, alcohol, ether, and dilute acids.

Soluble albumen is coagulated and converted into the insoluble form by most of the acids, when they are added to the solution of albumen in slight excess. Organic acids, however, with the exception of tannic acid, do not precipitate albumen from its solutions.

Albumen exhibits, with most tests, the same characters as other proteine-bodies. The following phenomena presented by it are worthy of note:—

1. Albumen is completely dissolved when exposed to the action of a solution of caustic potash or soda; the solution has a yellowish colour, and contains the albumen in an altered state. On neutralising the alkali with an acid, the dissolved albumen is thrown down, and sulphuretted hydrogen, proceeding from the sulphur contained in the modified albumen, is evolved.

2. Concentrated acetic acid, assisted by heat, also dissolves albumen; and in this solution ferrocyanide and ferricyanide of potassium throw down peculiar precipitates.

3. A violet-red coloured fluid is produced when albumen is heated with concentrated hydrochloric acid, and, better still, with the addition of a little sulphuric acid.

4. Concentrated nitric acid colours it yellow when heated. (Xanthoproteic acid.)

5. A solution of one part of mercury in two parts of nitric acid containing four and a-half equivalents of water (sp. gr. 1·41), is the most delicate test for albumen, as well as for all proteine-bodies, whether dissolved or undissolved. An albuminous fluid, heated with this solution of mercury to from 60° to 100° C. (140° to 212° Fahr.), becomes of an intensely red colour, which does not disappear on exposure to the air, or after long boiling.

6. Albumen becomes of a brownish-yellow when a solution of iodine in acid hydriodic acid is added to it. This reaction is especially well observed under the microscope.

7. Heated on platinum foil, albumen rapidly becomes brown—swells up and gives off an odour like that of burnt horn. The bulky carbonaceous mass remaining is burnt with difficulty, and leaves a greyish ash, consisting chiefly of lime and phosphoric acid.

8. Albuminous bodies subjected to dry distillation, as well as under the influence of oxidising agents, and when undergoing putrefaction, are decomposed into a number of new compounds—amongst others, into formic acid and acetic acid, into fatty acids, butyric and valerianic, benzoic acid, oil of bitter almonds, and into two crystalline compounds, leucine and tyrosine.

9. A solution of albumen, heated in a test-tube over a spirit lamp, becomes turbid at a temperature of about 75° to 80° C. (167° to 176° Fahr.). The coagulation commences at the surface of the fluid, and then extends gradually downwards through the tube. A white flocculent coagulum, which, under certain circumstances, is more or less coloured, is thus formed, the albumen passing into an insoluble form. Several points are worthy of notice in reference to this simple test:—When the solution of albumen is very much diluted, the turbidity will often appear only at a boiling heat; and to obtain a distinct coagulum, it may be necessary to boil it for a long time, and then allow it to stand. When the fluid has a slightly acid reaction, and provided there be no excess of acid present,

omplete coagulation usually occurs. But if the solution be neutral r slightly alkaline, heat often occasions merely a slight turbidity, ven though a considerable quantity of albumen is present. In such ase, the albumen remains in solution with the alkali. If, however, efore heating the solution, acetic acid is added to neutralise the lkali, the albumen is completely coagulated and thrown down in large flocculi. Care should be taken not to add an excess of the acid, because albumen is more or less dissolved by free acetic acid during the boiling.

The coagulum thus obtained is the insoluble form of albumen, and comports itself, in relation to solvents, acids, and alkalies, as above described. When heated, and particularly when boiled, it is dissolved by acetic and hydrochloric acids,—the latter acid giving it a reddish-blue colour.

10. Dilute nitric acid added to albuminous solutions throws down a white precipitate of nitrate of albumen, which is soluble in a large quantity of water—an important fact. Other mineral acids produce a like effect.

11. Strong alcohol produces complete coagulation of albumen in solution. Dilute alcohol occasions a precipitate, but does not convert the albumen into its insoluble form.

12. Most of the metallic salts, and likewise alum, occasion differently constituted precipitates. The precipitate caused by sublimate of mercury is of especial interest.

13. Sugar and concentrated sulphuric acid become of a beautiful red colour with all proteine-bodies, just as happens in the case of gallic acid. (See *Gallic Acid.*) Schultze.

14. An albuminous solution turns the plane of polarisation to the left. Hoppe availed himself of this property of albumen for its quantitative determination. The divergence, which is proportional to the degree of concentration, is as marked as in the case of a solution of grape-sugar of similar percentage.

15. Albuminous bodies, treated with a solution of sulphate of copper, and heated, after the addition of caustic soda or potash, imparts to the solution a beautiful violet colour. The reaction does not take place, or at all events is imperfect, if the alkali is added before the salt of copper.

c. *Tests.*—The presence of albumen in the urine is ascertained by a very simple process, which, if carefully performed, leads to positive results. The reaction of clear or previously filtered urine is first tried, and a test-tube, half full of it, is then heated over a spirit lamp. If it contains albumen and has an acid reaction, the surface of the urine becomes turbid when the heat exceeds 70° C. (158° Fahr.), and coagulation of the albumen quickly follows. If the urine be either neutral or alkaline, the coagulation will not take place, for reasons above given, or there will be at most only a milky turbidness. But if before heating we add to the urine a little acetic acid, carefully avoiding an excess, a flaky coagulation will take place in the urine when boiled. If, again, the urine be very acid, and contains, for instance, free hydrochloric or nitric acid, which may readily happen when these acids have been taken internally, boiling may fail to produce coagulation of the albumen. To obtain the albumen in such case the urine must be, first of all, sufficiently neutralised with very dilute ammonia. When all these precautions have been taken, if we obtain, on boiling the urine, a turbidity or precipitate, which on cooling is not dissolved by nitric acid, we may consider the absence of albumen in it demonstrated.

Cases, however, are occasionally met with, in which a precipitate is formed on boiling the urine (particularly if the urine is only slightly acid or neutral), but in which, nevertheless, no trace of albumen is present. Such precipitate consists of phosphatic earths, which in slightly acid urine are generally held in solution by the free carbonic acid. On the expulsion of the gas by boiling, the phosphates are precipitated in a flocculent form, and can then scarcely be distinguished by the eye from coagulated albumen. All doubt as to its nature is immediately removed by the addition of a few drops of dilute hydrochloric acid to the urine (when cooled), in which the precipitate is suspended. If the precipitate consists of phosphates it will immediately disappear, and leave the fluid clear, but if of albumen, it will remain unchanged. This state of the urine very frequently occurs, and therefore the subsequent testing with nitric acid should never be omitted, whenever any slight turbidity results from boiling.

A second specimen of the clear or previously filtered urine is treated with one fourth its volume of pure, moderately-concentrated, nitric acid. A distinct turbidity of the fluid thereupon results, if only a very small quantity of albumen be present, and a dense white precipitate if the quantity be considerable.

The test with nitric acid may, according to Heller, be also applied in the following very neat way: A little pure concentrated nitric acid is poured to a champagne-glass, and the urine to be tested then allowed, by means a pipette, to run down the side of the glass and spread over the surface the acid. When this is carefully done, the urine floats on the surface of e acid, and their admixture takes place slowly and gradually. In most ses, an intensely red, violet, or blue ring—the reaction of uroxanthine—esents itself at the point of contact of the two fluids. The observer must t consider this play of colours as a bile-pigment reaction, unless a green lour is distinctly visible under the blue. If the urine contains mere aces of albumen, this test exhibits at the part where the fluids come in ntact a circular turbidity well defined above and below. This reaction sts for some length of time; but the coagulated albumen at last sinks to he bottom of the glass. A turbidity, which at the first glance seems of a milar nature, may occur, when the urine is rich in urates. In this case, lso, a ring-shaped turbidity is formed; but the ring is placed higher than he position of the albuminous ring. The lower and also well-defined border es higher than the point of contact of the two fluids, and generally also igher than the upper border of the albumen turbidity; moreover, it is not rell-defined *above*, but vanishes gradually towards the surface of the urine. f the urine contains albumen, and at the same time a large quantity of rates, two rings may be formed—a lower albuminous ring, which is gene-ally separated by a clear layer from the upper stratum of turbidity formed y the urates. In such case, it is better, previously to testing, to dilute the rine with two or three parts of water, in order to prevent the reaction with he urates, or at least to reduce it to a minimum. Turbidity caused by rates also disappears when the urine is gently heated, and all doubts as o its nature are thereby at once removed. In very concentrated urine a recipitate of nitrate of urea may also take place; but it is of a crystalline orm, and immediately disappears on the addition of water.

APPENDIX.

SECTION XX.

Fibrine—another of the proteine-bodies—is sometimes met with in he urine, appearing in the form of large coagula, particularly in cute inflammations of the kidneys and urinary passages. Urine of his nature always contains blood, and is consequently albuminous lso. The peculiar tubular cylinders, which Frerichs regards as compressed fibrinous coagula, will be treated of under the head of *Sediments*.

Cases are also occasionally met with in which fibrine is separated rom the urine, partly in gelatinous masses, and partly as granular or thread particles.

The presence of caseine in the urine has not yet been distinctly shown.

Proteine bodies also, differing in their characters from ordinary albumen, are sometimes found in the urine. Thus Dr. Bence Jones [illegible] relates the case of a man suffering from mollities ossium, in whose urine he found, [illegible] a peculiar albuminous substance, which was not coagulated by boiling, was precipitated by nitric acid, and then redissolved when heated, separating, however, from the fluid as it cooled. The substance, when subjected to the other tests for albumen —such as acetic acid and ferrocyanide of potassium, and concentrated hydrochloric acid—proved it to be a proteine-compound; but its peculiar action with water and nitric acid forbid its classing it either under the head of albumen or caseine—at least so long as we are unable artificially to induce albumen or caseine to undergo this peculiar modification.

Bayon described, under the name of "albuminose," an albuminous substance which, according to him, is also present in healthy urine. This substance, Mialhe says, conducts itself in reference to albumen as does glucose to amylum [illegible]. Albuminose is precipitated by tannin and several metallic salts, but not by heat, or acids, or alkalies. It is, as asserted, always present in healthy urine, and also in its abnormal states. In a case of Bright's disease, however, in which the urine contained much albumen, no albuminose was found. Bayon pointed out tartrate of copper as being a very sensitive test of albuminose. The urine, after the addition of a few drops of potash-ley, is boiled, filtered, and a solution of tartrate of copper added, until the mixture assumes a lightish blue colour. In the course of an hour or two the tartrate of albuminose [illegible] is precipitated; it may be re-dissolved by heat, but again separates as the fluid cools. (*Canstatt's Jahresbericht*, 1860, p. 270.)

SECTION XXI.

DIABETIC SUGAR.—GRAPE SUGAR.

Composition.—In 100 parts:—

Anhydrous—	Carbon	40·00	Crystallised—36·36
	Hydrogen	6·66	7·07
	Oxygen	53·34	56·57
		100·00	100·00

Formula: $C_{12} H_{12} O_{12}$ $C_{12} H_{12} O_{12} + 2 H O$

A. *Occurrence.*—Grape-sugar, which is perfectly identical with sugar of urine, is found extensively distributed throughout the vegetable kingdom. It is also found normally in animals, and in some of the fluids of the body in its diseased conditions. It is, for instance, always present in the contents of the small intestines and in the chyle, after saccharine or amylaceous food has been taken; in the hen's egg, whether hatched or unhatched, and in the yolk as well as in the white; and also in the amniotic and allantoic fluids of cattle, sheep, and pigs, and in the liver. Sugar, again, has been frequently found in the blood, and particularly in the blood of the hepatic veins. According to Lehmann's latest observations, the blood of the vena portæ contains no sugar; consequently, the formation of the sugar must take place in the parenchyma of the liver.

As, then, there is no doubt that sugar is normally formed in the body, and that its appearance in any of the excretions is abnormal, except, perhaps, in the merest traces, we are necessarily led to the conclusion that it gradually undergoes further changes in the body, passing through several intermediate forms with which we are not yet acquainted, and that it is at last completely oxidised, and passes away from the body in the form of water and carbonic acid.

The numerous researches of Brücke seem clearly to show that healthy urine frequently contains traces of sugar. The sugar, however, only appears in large quantities in cases of diabetes mellitus, and in such cases is found to be increased also in the blood, the matters vomited, the saliva, the sweat, &c. In other diseases sugar is also occasionally found, as for example, in cases of disturbance of the abdominal circulation. Injury of certain parts of the medulla oblongata in animals again will produce a temporary attack of diabetes. According to Lehmann, saccharine urine is observed in women twenty-four to forty-eight hours after weaning.

B. *Microscopical characters.*—Diabetic sugar usually crystallises in confused masses, which have the appearance of wart-like conglomerations, and consist of small plates grouped in a cauliflower form. These plates have a rhombic character. But if the separation of crystals takes place rapidly from a solution, the crystals appear, under the microscope, not in the form of plates, but of irregular, striped, and roundish masses.

C. *Chemical characters.*—Pure grape-sugar is white, and without smell; its taste is not nearly so sweet as that of cane-sugar, neither is it so soluble in water. Its solution has no action on vegetable [illegible] the plane of polarisation to the right. It is com[illegible] in water, but moderately soluble in alcohol. Crystallised grape-sugar exposed for some time to a heat of 100° C. and [illegible] loses with its water of crystallisation (2 eqs.). Cane-sugar exhibits the same action with polarised light: its aqueous solution causes a divergence of the rays to the right, and herein it agrees with crystalline grape-sugar, even to the degree of the divergence. When, however, the watery solution of cane-sugar is digested for some time with dilute sulphuric acid, the sugar takes a modified form of grape-sugar, whose solution causes a divergence of the polarised ray to the left. This peculiar property of sugar is referred to, because it has been made of use in the quantitative analysis of sugar; the greater or less degree of the divergence in equal volumes of the saccharine solution indicating the amount of sugar present in it. It is hardly necessary to say that the degree of divergence must be previously determined in solutions, the amount of whose saccharine contents is accurately known.

2. Grape-sugar, when heated to 140° C. (284° F.), is converted into caramel. At a higher temperature it yields acid products of distillation, and leaves a voluminous shining ash, which is burnt with difficulty.

3. In contact with nitrogenous bodies, and especially with caseine, grape-sugar undergoes the lactic acid-, and afterwards the butyric acid-fermentation. In diabetic urine, even at a moderate temperature, though more rapidly at 25° to 40° C. (77° to 104° Fahr.), the sugar turns to an acid, which, according to circumstances, is acetic, butyric, or lactic acid.

4. Digested with nitric acid, grape-sugar is converted into oxalic and saccharic acids.

5. With many bases it forms peculiar compounds,—so-called saccharates:

a. Potash-glucose.—$2\,KO + C_{12}H_{12}O_{12}$. This compound is readily obtained by the admixture of an alcoholic solution of sugar with a solution of caustic potash in alcohol. It is immediately thrown down in the form of white flocculi, which, when exposed to the air, become tenacious, adhere together, and take up carbonic acid.

b. Lime-glucose.—This compound is obtained as a white mass when an excess of caustic lime is added to a solution of the sugar, the mixture filtered, and the filtrate treated with alcohol.

c. Chloride of sodium-glucose.—$2\,(C_{12}H_{12}O_{12})\,NaCl + 2\,HO$.

A solution of grape-sugar, mixed with a solution of chloride of sodium, and allowed to undergo spontaneous evaporation in the air, crystallises in large colourless, four-sided double pyramids. These crystals are hard, and easily pulverised; they dissolve readily in water, but with difficulty in alcohol. They contain 13·3 per cent. of chloride of sodium.

6. A solution of the sugar, digested with caustic potash or soda, becomes of a beautiful reddish-brown colour, and if nitric acid be then added to it, it emits a pungent, sweetish odour, somewhat resembling that of caramel and formic acid.

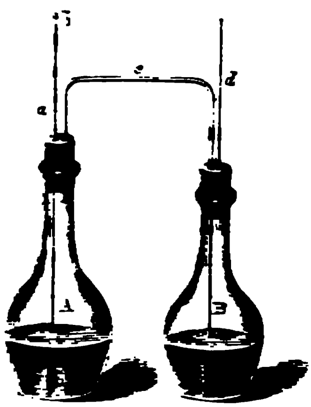
7. A solution of indigo-carmine rendered alkaline by carbonate of soda, and boiled with a little grape-sugar, becomes coloured, if only a small quantity of sugar be present; the solution is first of all green, then purple-red, and if more sugar be added, of a red, and lastly, of a yellow colour. If the hot yellow solution be now shaken up, so as to bring it under the action of the oxygen of the air, the play of colours goes on in an inverse course. The mixture takes a purple-red, then a green, and lastly, once again a blue colour; if, however, it be allowed to stand for a short time the yellow colour will reappear (Mulder). This reaction is a very brilliant test, and is capable of determining the presence of a very small quantity of sugar. If only traces of sugar are present, of course only a very weak blue-indigo solution must be employed.

8. When a little caustic potash and a few drops of a solution of sulphate of copper are added to a solution of the sugar, either no precipitate is formed, or that which is formed is again re-dissolved, and imparts a beautiful blue colour to the liquid. This fluid, when heated, takes, first of all, an orange-red colour, it then soon becomes muddy, and finally throws down a dirty red precipitate of suboxide of copper. The oxide of copper is, in this process, reduced by the alkaline solution of sugar, and the oxygen which is separated acts as an oxidising agent upon the sugar.

This reaction will take place, after long standing, without the application of heat and even in the cold. Uric acid, hypoxanthine, mucus, &c., also, under heat, effect the reduction of oxide of copper with separation of red suboxide of copper. It should, however, be remarked, that many bodies, when present, prevent the separation of the suboxide of copper, as, for example, albuminous matters, such as peptone, creatine, creatinine, pepsine, trimethylamine, and ammonia, or compounds which when heated with potash give off ammonia.

9. Fermentation is soon observed to commence in a solution of sugar, to which a little yeast has been added, particularly if the fluid be kept at a moderate degree of heat, 12° to 25° C. (53° to 77° Fahr.). The process may be readily observed in the following way:—

FIG. 1.



A is a small flask, into which the sugar is introduced with the yeast. The flask is made to communicate, through the tube *c*, with the flask B, which is half-filled with lime- or baryta-water. The tube *a* is closed above by a bit of wax at *b*. When the mixture in A is warmed to the temperature mentioned, the solution of sugar soon becomes turbid; a distinct scum forms on its surface, and gas is given off. This gas is carbonic acid, which is separated in the form of carbonate of baryta or of lime, on being passed through the solution of lime or baryta. When the evolution of gas ceases, the fluid in A becomes clear, loses its sweet, and assumes a vinous, taste. The sugar is decomposed into alcohol and carbonic acid.

When the quantity of sugar is very small, the fermentation-test may be employed in the way described by Lehmann. A long and widish test-tube is filled to one-fourth with quicksilver, and the fluid to be tested slightly acidulated with tartaric acid, and mixed with a little well-washed yeast, poured on it to overflowing. The tube is closed with a caoutchouc cork, through which a narrow glass tube is passed down into the mercury at the bottom of the tube, its external upper extremity being bent to an acute angle. This apparatus is then warmed to a temperature of from 30° to 40° C. (86° to 104° Fahr.). If the solution contains sugar capable of undergoing fermentation, carbonic acid will very soon be evolved, and collecting under the stopper, will force the mercury up through the narrow tube. The nature of the gas may be at once ascertained by the action of lime-water.

10. A solution of grape-sugar treated with a weak ammoniacal solution of nitrate of silver, and boiled for a short time, throws down

metallic silver in the form of a bright metallic mirror. The reduction is not prevented by the presence of ammonia, and may therefore be of service under certain circumstances. It must not, however, be forgotten, that many other bodies, such as tartaric acid, &c., reduce the silver in a similar way.

11. A solution of bi-chromate of potash, containing a little free sulphuric acid, mixed with diabetic urine, imparts to the mixture, when heated, a characteristic bluish-green colour. (Krause).

12. To test the urine for sugar, according to Böttcher's method, the urine is poured into a test-glass, and mixed with an equal volume of a solution of carbonate of soda (three parts water, one part crystallised $Na\,O, C\,O_2$); to this is added a little basic nitrate of bismuth, and the whole then heated to boiling. If the snow-white salt of bismuth now assumes the slightest shade of dark or grey, the presence of diabetic sugar in the solution is positively indicated; for, according to Böttcher, there is no other constituent of the urine which acts as a reducing agent on this salt of bismuth. The urine, however, must be absolutely free from albumen; for if it is present, black sulphuret of bismuth readily forms and may create confusion. This test also serves to distinguish cane- from grape-sugar, as cane-sugar does not occasion a similar reduction.

D. *Tests.*—Different methods are employed for testing the presence of sugar in the urine, according as the quantity of sugar which it is supposed to contain is greater or less. If the quantity of urine passed in the twenty-four hours is large, for example four or five litres—if the colour is greenish-yellow, and the specific gravity high, above 1·020, the urine to be tested is most probably diabetic. In such a case the presence of the sugar is easily shown, for diabetic urine comports itself with almost all tests, as a pure solution of sugar. When, therefore, the urine is free from albumen, which must be previously determined (Sect. 19), the different tests for grape-sugar may be directly employed. If albumen be present, it must be separated according to the directions given (Sect. 19). In testing for sugar we proceed as follows:—

1. Fifteen to twenty drops of the urine are diluted with 4 to 5 C. C. of water, ½ C. C. of caustic soda or potash added, and a very dilute solution of sulphate of copper dropped into it. If sugar is present, the precipitate which at first forms is re-dissolved on shaking, and the fluid becomes of a clear blue colour. This blue solution is then heated nearly to boiling, whereupon a yellow cloud

forms, which soon, and without further heat, is followed by a separation of yellow or red suboxide of copper. Care must be taken not to heat the mixture of urine and potash-ley before the addition of the copper-solution, as thereby the sugar, and especially if the quantity of it is small, may be so altered as to be rendered incapable of reduction by the copper salt.

A second mixture, similarly prepared, is left at rest for six to twenty-four hours, without being heated, and, if sugar is present in it, a separation of suboxide of copper will also take place. This counter-test is of importance, and should never be omitted; for most of the bodies, which (like sugar) reduce the solution of copper, require heat or long boiling for the reduction. Diabetic sugar, on the other hand, reduces the copper without heat.

2. A second specimen of the urine is diluted with an equal quantity of carbonate of soda solution, a small quantity of trisnitrate of bismuth added to it, and the mixture boiled for a long time. A complete or partial reduction of the oxide of bismuth will follow, according to the amount of sugar present, and consequently a grey or black colouring be produced. When the quantity of sugar is small, only a very little bismuth should be employed; otherwise, the reduction being slight, it may be concealed by the excess of the white salt. If the tested urine is now left at rest, the undecomposed oxide of bismuth first sinks to the bottom, and the reduced bismuth is then distinctly seen deposited upon it in the form of a beautiful black-velvety ring.

3. Another portion of urine is poured into a long but narrow test-tube, a little caustic potash solution added, and the fluid in the upper part of the tube heated to boiling. If sugar be present in the urine the boiled portion of the fluid becomes of a brownish-red colour, whilst the lower part of it retains its original appearance. The slightest change of colour may be distinctly observed in this manner. This reaction is highly serviceable as a confirmatory test.

Further proofs may be obtained by the tests 7 and 10, and especially by the fermentation-test, which may be applied by the aid of the apparatus shown in Fig. 1.

The sugar may be readily obtained from diabetic urine in a pure crystalline form: for this purpose the following processes are employed:—

I. The urine is evaporated to the consistence of syrup in a water bath, and the residue left at rest until the sugar has become crystallised in the form of yellowish, warty masses. From this crystalline mass the urea and

rated by the aid of absolute alcohol; and the
the residue by boiling it with spirits of wine
The sugar thus obtained is in a tolerably
from all trace of alcohol by repeated crystalli-

—A spirituous solution of the sugar is first
the urine, and by extraction with alcohol. The
dryness, the residue dissolved in water, and the
with chloride of sodium. The compound of
sugar crystallises on evaporation, and may be
crystallisation, in the form of clear translucent
are dissolved in water, and carefully precipitated
The choride of silver is separated by filtration, and
to dryness. The sugar may now be obtained
extraction with alcohol.
however, that these processes only succeed when
large quantity of sugar present in the urine. Cases
in which the sugar of the urine cannot be crystal-
it manifestly differs from glucose, as shown by the fact
plane of polarised light to the left. In such cases the
always retains its syrupy consistence, and exhibits no

urine, when tested, does not offer the characteristics
if on being heated it reduces the copper solution
ing any separation of suboxide of copper, and with
a slight yellowish coloration of the mixture, it is
order to satisfy ourselves of the presence of sugar, to
pure a form as possible, before applying the tests
Thus, for example, a slight reduction of the copper-
be produced by uric acid, when no sugar whatever
he urine. And even when the urine contains sugar the
be depended on, because traces of suboxide of copper
roduced through the ammonia which is evolved from urea
urine is heated with potash. In this case, however,
at most only a yellow coloration of the mixture, without
acteristic separation of suboxide of copper; and when the
is allowed to stand exposed to the air it becomes blue again
urface through oxidation.
oid these different sources of error, a large quantity of
00 to 800 C. C., is taken; any albumen present removed
9), and the filtrate evaporated, or if the urine contains no
it is filtered and evaporated in a water-bath to a thick
which is set aside four or six hours to cool. The residue is

then divided as finely as may be with pounded pumice-stone, extracted with alcohol (90 p. c.), which must be freely employed, frequently shaken with, and allowed to act upon the extract for some hours. An alcoholic solution of pure caustic potash is then added to the clear filtered fluid, so long as any separation follows, an excess of it, however, being avoided. If any sugar is present, the sugar-potash is precipitated as an adhesive, resinous-like mass, but always in combination with other crystalline or flocculent potash-compounds. After standing twelve hours the spirit of wine is decanted off, the precipitate, whether flocculent, crystalline, or resinous, repeatedly washed with absolute alcohol, and then dissolved in water, which, under all circumstances, is readily effected. In most cases the solution will at once give the required reaction; but as, under certain circumstances, substances are present in this potash-precipitate which are capable of reducing the oxide of copper, we cannot even yet be perfectly sure of the existence of sugar in the urine.

We therefore (as recommended by Lehmann) throw down the watery solution of the potash-precipitate, accurately neutralised with acetic acid, by a slight excess of acetate of lead, filter, remove any excess of oxide of lead with sulphuretted hydrogen, again filter, and evaporate the fluid, which is now in most cases as clear as water, to dryness in a water-bath. In this way all the sulphuretted hydrogen is removed. The residue is dissolved in water, and the test (No. 1) applied. If it gives distinct results, we may be sure that sugar is present; as it is scarcely possible that any other substance can be present in the fluid thus obtained which will give the sugar-reactions. In applying the copper-test the mixture is allowed to stand, so that if sugar is present the suboxide of copper will be separated without the application of heat. Only a small quantity of copper-solution should be employed, so as to impart to the mixture merely a light blue colour.

The last decisive proof of the presence of sugar is obtained by the fermentation-test, which, even when there is only a very small quantity of sugar in the urine, gives very satisfactory results, when applied by means of Lehmann's apparatus, above described ("Chemical Character," No. 9). If sugar is present the fermentation quickly takes place. In order to be sure that the gas evolved does not depend upon decomposition of the yeast, it is advisable to try a counter-test with yeast and pure water.

Leconte treats the potash-precipitate in the following way: a slight excess of tartaric acid is added to the precipitate, previously dissolved in the smallest possible quantity of water, the mixture shaken, the bi-tartrate of potash separated by filtration, and the filtrate, when cold, treated with chalk until it is perfectly neutral. The filtrate is then evaporated in a water-bath, and the residue exhausted with absolute alcohol. If sugar is present, this solution, on spontaneous evaporation, will leave a syrup, which after a long time, sometimes only after months, deposits crystals, which, indeed, often make up the whole mass. But if we are contented with the fermentation-test, instead of the extraction of the sugar, Leconte advises that the watery solution of the potash-precipitate should be simply treated to saturation with dilute sulphuric acid; the sulphate of potash which separates on standing, removed by filtration, a little water added with the yeast, and the fluid introduced into the apparatus.

Brücke makes use of the following methods for the finding of sugar in healthy urine:—

a. The urine, 1000 to 5000 C. C., is first of all precipitated with a concentrated solution of sugar of lead, filtered, acetate of lead added to the filtrate so long as any precipitate is formed, again filtered, and finally precipitated with ammonia. This last precipitate is collected on a filter, washed with water, and dried between thick layers of bibulous paper, which are changed from time to time. The broken-down caky mass is now first of all roughly rubbed down in a mortar with the aid of distilled water, and a concentrated solution of oxalic acid then added, the rubbing in the mortar being continually kept up until a filtered specimen of the mixture produces no turbidity. The filtrate is then saturated with finely divided carbonate of lime, the mixture again filtered, the filtrate slightly acidulated with acetic acid, evaporated to dryness, and the residue dissolved in a small quantity of water. To this solution Brücke applies the ordinary tests, as well as the fermentation-test. Dr. Bence Jones does not decompose the lead-precipitate as Brücke does, with oxalic acid, but in a more simple manner, viz., by passing sulphuretted hydrogen through the precipitate suspended in water. By this method Dr. Bence Jones found in many samples of normal urine—1000 to 5000 C. C.—notable quantities of sugar (2 to 3 grains in 1000 C. C. of urine).

b. The urine is treated with strong alcohol, so that the mixture [illegible] absolute alcohol. For this purpose 200 [illegible] C.C. of alcohol of 94 [illegible] the precipitate which [illegible] a beaker-glass. An [illegible] to the filtrate [illegible] litmus-paper shows a [illegible] The beaker-glass, well covered, [illegible] the cool. The next [illegible] glass reversed on filtering [illegible] absorbed, and allowed to [illegible] of alcohol. The [illegible] be found partly [illegible] dissolved in a very small [illegible] for the application of [illegible]

[illegible] uric acid may find its [illegible] always advisable to acidulate the [illegible] acid, and allow it to [illegible] for the purpose of separating any uric [illegible] The neutralised filtrate is then sub[illegible] as also, when pos[illegible]

[illegible] all separated from the [illegible] mass by means of tar[illegible] removed from the filtrate by [illegible] with which the fluid is left [illegible] of lime and any excess of car[illegible] been added, are then separated [illegible] used for the application of the [illegible]

APPENDIX.

SECTION XXII.

ALKAPTON.

Boedeker found a peculiar substance in the urine of a man, 44 [illegible] who after an attack of typhus suffered from repeated attacks of cough and expectoration. This substance (to which he gave the name of alkapton), when an alkali is present, absorbs a large quantity of oxygen and becomes of a brown colour. The patient at the time suffered severe pains in the back, passing down to the lower dorsal vertebræ, and thence round the body as a lumbo-abdominal neuralgia. The quantity of urine was about 1500 C. C. in the twenty-four hours, its sp. gr. 1·020 to 1·025, and contained not more than 1 per cent. of sugar. On the addition of caustic-potash the reddish-yellow colour of the urine changed (from above downwards in the test tube) into a dark brown, a large quantity of oxygen being at the same time absorbed, of which fact Bödeker satisfied himself by a special experiment. The copper solution was strongly reduced by the urine.

Preparation.—The urine passed during ten days—15,000 C. C.—is precipitated with sugar-of-lead solution, and the filtrate treated with basic acetate of lead as long as any precipitate falls. The filtered mixture is no longer rendered brown by caustic potash, but shows a slight reaction of the copper reduction. Sugar, however, is not precipitated by acetate of lead; it therefore remains in solution whilst the alkapton is thrown down. The lead-precipitate is decomposed with sulphuretted hydrogen, and the filtrate as thus obtained is evaporated to dryness in a water bath for the purpose of separating the hydrosulphuric acid, it is then triturated with powdered sulphate of baryta, and exhausted with ether. On evaporating the ether a dark brown mass is left, in which, after several days, crystals of hippuric acid are formed. On solution in a little cold water the crystals of hippuric acid are left, together with a brown mass. The watery filtrate possesses in a high degree the power of reducing oxides of copper and silver with caustic potash, but it is still very dark. The aqueous solution is therefore once more treated with sugar-of-lead solution, the filtrate precipitated with acetate of lead, and the washed precipitate then decomposed with sulphuretted hydrogen. The filtrate, when evaporated, leaves the alkapton in the form of a golden-yellowish, resinous, transparent mass, without a trace of crystallisation. Heated with soda-lime, much ammonia is evolved. The alkapton is soluble in all proportions in water and alcohol, very slightly soluble in ether free from water, but more so in ether containing water.

The golden-yellowish solution has a slightly-acid reaction, and possesses the following characters :—

1. Caustic alkalis, potash, soda, and ammonia occasion in it neither change of colour nor precipitate when the air is excluded; but when oxygen is allowed to act on it and the solution is concentrated, the brownish-yellow is invariably converted into a brownish-black colour.

2. Sugar-of-lead solution has no effect on it; acetate of lead produces a well-marked white precipitate, which on exposure to the air gradually assumes somewhat of a brownish-violet colour.

3. Boiled with Fehling's copper solution, changes occur in it which vary according to the relative amount of copper solution and the substance reduced. If only so much of the copper solution be used as to give the fluid when boiled a blue or merely a greyish-blue colour, the whole of the reduced suboxide of copper may remain in solution and render the mixture of a yellowish colour. But if the solution is boiled with an excess of copper solution, suboxide of copper will be at once separated, at first of a yellow and then of a beautiful red.

4. Mixed with yeast, the alkapton solution shows no sign of fermentation.

5. A drop of nitrate-of-bismuth solution is treated with an excess of soda and the mixture poured into two test-glasses, to the one alkapton alone is added, and to the other alkapton mixed with a trace of diabetic sugar. When the first test is boiled the fluid merely becomes of a brownish colour; the oxide of bismuth certainly throws down somewhat of a brown mass, which is formed by the oxidating action of the air, but this is not to be compared with the perfect reduction of the bismuth in the second tube, to which the sugar has been added. The alkapton also behaves like uric acid in relation to the copper solution and oxide of bismuth when an excess of soda is present, in so far as that the uric acid is able to reduce the oxide of copper to a state of suboxide, but not the oxide of bismuth. By this character of alkapton, in addition to its behaviour under the action of oxygen in an alkaline solution, we are able to distinguish it from sugar, and to ascertain the presence of sugar as well as of alkapton. (Annal. d. Chem. u. Pharm., vol. 117, page 98. Zeitschrift f. Ration. Med. von Pfeuffer u. Henle, 3rd Series, vol. 7, p. 130.)

SECTION XXIII.

INOSITE.

sition :—

In 100 parts :	Carbon	40·00
	Hydrogen . . .	6·66
la : $C_{12} H_{12} O_{12}$	Oxygen . . .	53·34
llised : $C_{12} H_{12} O_{12} + 4 HO$.		100·00

ccurrence.—Until lately inosite has been found only in the of muscle. Cloetta has, however, recently discovered this able hydrate of carbon in the lungs (together with uric acid, , and leucine), in large quantities in the kidneys also (with and hypoxanthine); in the spleen (with uric acid, hypoxan- and leucine); and in the liver (with uric acid). Cloetta also tly showed the presence of inosite in the urine in a case of 's disease; he could not, however, find it in healthy urine. mm found inosite most abundantly in the brain; he also ith it in the kidneys, and in diabetic urine which contained a uantity of sugar. Vohl met with a case of diabetic urine in the sugar was gradually replaced by inosite. According to inosite is identical with phaseomannite discovered by him in beans (*phaseolus*).

icroscopical characters.—Inosite usually forms cauliflower-like s, massed together, in groups; sometimes, however, single s are found three to four lines in length. These crystals belong klinorombic system. (Funke, *Plate VI. Fig.* 6.)

hemical characters.—Inosite loses its water of crystallisation in , and melts at 210° C. (410° Fahr.). It has a distinctly sweet dissolves readily in water, and is insoluble in ether and alcohol. used inosite hardens into needles when quickly cooled, but slowly cooled, into a horny mass.

nosite does not produce alcohol when yeast is added to it. putrid cheese it yields lactic and butyric acids.

When a solution of inosite is evaporated with nitric acid to dryness on platina, and the residue, moistened with a mmonia and a solution of chloride of calcium, again cautiously ated to dryness, a lively rose-red colour appears, which is , even though only ^{1} of a grain of inosite be present. The gars do not give this reaction.

When inosite is boiled with a solution of acetate of copper in caustic-potash, reduction of the copper does not take place, as in the case of grape-sugar; but a green solution results, from which, after a time, a flocculent, greenish precipitate is separated, the upper part of the fluid becoming blue. If the precipitate is separated by filtration, and the filtrate again boiled, the same play of colour will be again observed. (Cloetta.)

5. Neutral acetate of lead does not throw down a precipitate with solution of inosite; but basic acetate of lead produces in it, when a warmed, a transparent jelly, which becomes white in the course of a few minutes, and assumes the exact appearance of paste. This is an excellent method whereby to separate inosite from animal fluids.

D. *Tests.*—Inosite, as already observed, has been found in the urine of Bright's disease and in diabetic urine. The urine to be tested for inosite is completely precipitated with sugar of lead, filtered, and the warm filtrate treated with basic acetate of lead as long as any precipitate is formed. It is better that the urine should be concentrated to one-fourth before it is precipitated. The lead-precipitate collected after twelve hours' standing is washed, suspended in water, and then decomposed by sulphuretted hydrogen. After the filtrate has been left at rest a short time, a small quantity of uric acid separates from it; this is removed by filtration, and the fluid so concentrated as to remain permanently turbid when treated with an equal volume of alcohol. It is then heated until the turbidity disappears, and allowed to stand one or two days. The crystalline mass thus obtained is purified by re-crystallisation, and then subjected to the tests of nitric acid, ammonia, and chloride of calcium, as well as of tartrate of copper. When the materials for operating on are abundant, the other tests may be employed as confirmatory.

SECTION XXIV.

BILE.

The bile-pigments and the acids of the bile are found in the urine
thological states of the body, as, for example, in jaundice. In
onia again, the bile-acids have been occasionally met with in
ne unaccompanied with the bile-pigments. Cholesterine ap-
be occasionally present in the urine in cases of fatty
tion of the kidneys.

y, and especially in severe cases of jaundice, it is found in almost
he fluids of the body, and even in the tissues themselves.

ery little is yet known of the chemical nature of the bile-pig-
t, although from certain reactions it is clear that it undergoes
rent modifications, which are probably the products of the
sformations or oxidation of some one primitive substance.

. *Cholepyrrhine.—Brown-pigment.* — This is the bile-pigment
t frequently met with, and appears, indeed, to be the primary
n. Cholepyrrhine consists of a reddish-brown powder, without
e or smell, dissolves with difficulty in water and ether, but more
lily so in alcohol. The alcoholic solution, which is originally
wn, becomes gradually green when exposed to the air. Chole-
rhine, moveover, is soluble in alkalies. The feebly alkaline
ituous solution becomes of a beautiful green on the addition of
rochloric acid; the colour becomes of a bright blue on the
ition, *guttatim*, of nitric acid. The colouring-matter of fresh
always assumes the green form of pigment when exposed to the
on of the oxygen of the air, as well as when treated with acids.
action of cholepyrrhine, when treated with nitric acid contain-
nitrous acid, is particularly interesting.

Vhen red fuming nitric acid is dropped into a solution of brown
nent, without disturbing the mixture, a zone of colours is formed
he lower part of the fluid, which passes through the shades of
n, blue, and violet, into red, and finally becomes of a dirty
ow. In this process the colouring-matter is entirely altered.

holepyrrhine appears to be chemically identical with the bilifultions of blood, a fact of high physiological significance. The chloroform solution, tested with nitric acid, exhibits in a beautiful manner the play of colours mentioned above as characteristic of bile-substances. Hence, then, we possess in chloroform an excellent and certain means of discovering the presence of bile-pigment in other fluids, &c.

b. Biliverdine (green-pigment) is the form of pigment into which cholepyrrhine often passes, and into which, indeed, it may be converted. It is a dark-green amorphous substance, without smell or taste: it is slightly soluble in alcohol, but insoluble in water; in ether it dissolves with a red colour. Hydrochloric and sulphuric acids in dissolving it become of a green colour.

When a solution of biliverdine is precipitated with acetate of lead, and the precipitate, after washing and drying, is extracted with alcohol containing sulphuric acid, the alcoholic mixture is found when filtered tinged of a green colour.

A precipitate of a bluish-green appears, when soluble albumen is added to a fluid containing biliverdine, and nitric acid employed in sufficient quantity to produce its coagulation.

The presence of cholepyrrine in urine may be shown even after several days, by the action of nitric acid, provided the air be perfectly excluded. If, however, the urine is heated in an open basin, the brown pigment is gradually converted into biliverdine, and its presence can no longer be shown by nitric acid, which, under such circumstances, fails to produce the reaction described.

c. *Tests.*—Urine containing bile-pigment is always tinged of a deep brown, reddish-yellow, greenish-brown, or dark or grass-green colour. Much froth is formed in it when shaken; and it imparts a yellow or greenish colour to a slip of filtering paper when dipped into it.

a. Test for cholepyrrhine.—A conical-shaped test-glass is filled with urine, and nitric acid, containing nitrous acid, carefully added to it, each drop of the acid being allowed to trickle down from the rim of the glass, and great care taken to prevent the fluid being shaken. If cholepyrrhine is present, we find that at the top of the glass, and particularly at the point where the two fluids come into contact, a zone of colours is formed, which passes from green into blue, violet, and red, and, lastly, into yellow. If, in consequence of there being only mere traces of the colouring-matter present, this reaction with nitric acid does not take place, it may be produced by adding to the mixture equal parts of nitric and sulphuric acids, instead of nitric acid; or, according to Brücke, to make the test still more certain, by adding, first of all, a few drops of nitric acid to the urine, so as to give to it a green colour, and then allowing 20 or 30 drops of concentrated sulphuric acid to trickle down into the urine from the side of the test-glass, so as not to mix with the urine, but to sink down to the bottom of the glass. The test, however, succeeds best, even though the quantity of bile-pigment is very small, when applied as follows:—Concentrated nitric acid, slightly decomposed by exposure to the light, is poured to about an inch high into a conical-shaped test-glass, and a little of the urine to be tested carefully spread over its surface by means of a pipette, pouring it on the border of the glass. If cholepyrrhine is present the play of colours commences at the line where the fluids come in contact with a beautiful green ring, which gradually extends upwards, and at its under surface exhibits a blue, violet-red, and, lastly, a yellow ring (Kühne). It should, however, be observed, that the whole of these colours do not invariably appear; violet and green generally last the longest; but the green which appears almost at the commencement of the action is alone demonstrative of the presence of bile-pigment; the red and violet rings may be also produced by uroxanthine (indican), and the products of its decomposition. (See *Uroxanthine.*) The presence of albumen in no way interferes with this test; a portion of the pigment is generally precipitated with the albumen, which is coagulated by the nitric acid, but it also beautifully shows the reaction. The nitric acid must not contain too much nitrous acid, for if it does the reaction is violent, and the play of colours rapidly passes away.

The slightest traces of bile-pigment may be discovered, should the above test fail, by shaking large quantities of urine successively with chloroform, and pouring off the exhausted urine. The smallest quantity of cholepyrrhine present in the urine is taken up by the chloroform, which, when left at rest, by reason of its high specific gravity, rapidly sinks to the bottom, of a yellowish colour. The supernatant urine is drawn off, and a little nitric acid containing nitrous acid spread over the chloroform solution. If the slightest trace of cholepyrrhine be present, the reaction will then take place (from above downwards), and in a very brilliant form. Another portion of the chloroform-solution is evaporated in the air, and the residue examined microscopically; if any brown bile-pigment is present, single reddish-yellow crystals of cholepyrrhine are readily distinguished. (Valentiner.) The reaction with nitric acid in the chloroform solution is excessively delicate and beautiful.

SECTION XXV.

2. Bile-acids.

The starting-point of all the acids contained in the bile is cholic acid—a non-nitrogenous compound—($C_{48}\,H_{39}\,O_9 + H\,O$). Cholic acid, when pure, usually crystallises in shining, colourless tetrahedra, and sometimes, though rarely, in rhombic forms.

Crystallised cholic acid, at a temperature exceeding 195° C. (383° Fahr.), gives off one equivalent of water, loses its crystalline character, and is converted into a resinous body—choloidic acid ($C_{48}\,H_{39}\,O_9$). It undergoes the same decomposition when boiled for a long time with hydrochloric acid.

Choloidic acid, the product of the decomposition of cholic acid, forms a white amorphous, resinous mass, which is insoluble in water, slightly soluble in ether, and readily soluble in alcohol. Choloidic acid melts at 150° C. (302° Fahr.); at 295° C. (563° Fahr.) it gives off three atoms of water, and is converted into another compound, dyslysine ($C_{48}H_{36}O_6$).

These two acids are not found in an isolated form in fresh, healthy, undecomposed bile, the cholic acid being always united with nitrogenous bodies—with taurine and glycocoll. Taurocholic and glycocholic acids may indeed be regarded as conjugates of cholic acid with taurine and glycocoll.

1. *Taurocholic acid* ($C_{52}\,H_{45}\,N\,O_{14}\,S_2$).—This acid, found in the bile in union with soda, has not yet been obtained in a crystalline state. In its partially impure state it forms a white amorphous powder, which is strongly hygroscopic, has an intensely bitter taste, dissolves readily in alcohol and water, and is insoluble in ether. Boiled for a long time with caustic potash, it is decomposed, the cholic acid uniting with the potash, and the taurine being set free. If hydrochloric acid is used instead of potash, the same separation takes place. The cholic acid, however, is not, in such case, separated as cholic acid, but by the action of the boiling hydrochloric acid, is converted into the resinous choloidic acid.

The taurine ($C_4\,H_7\,S_2\,N\,O_6$) which is separated, crystallises in the form of colourless, regular hexagonal prisms, terminating in four or six planes. (Funke, *Plate III. Fig.* 4.) Taurine is a nitrogenous body, containing 25 per cent. of sulphur. It dissolves readily in water, but only slightly in alcohol. Its solutions do not affect the vegetable colours. Strecker succeeded in producing taurine artificially, by simply heating to 220° C. (428° Fahr.), isethionate of ammonia ($C_4 H_9 S_2 N O_8 - 2 H O =$ taurine $C_4 H_7 S_2 N O_6$).

Taurine is obtained most conveniently in the following way :— Fresh ox-bile, freed from mucus, is evaporated with strong hydrochloric acid, and the choloidic acid thus separated. The chloride of sodium is crystallised out of the strongly concentrated fluid, and the mother liquid still further evaporated; from this the taurine is precipitated on the addition of double its volume of strong alcohol. The taurine may be obtained pure in the form of large beautiful crystals on re-crystallisation from water.

2. *Glycocholic acid* ($C_{52} H_{42} N O_{11} + H O$) also exists in healthy bile, in combination with soda. It crystallises in extremely fine needles (Funke, *Plate IV. Fig* 6), differing essentially, in this respect, from taurocholic acid. It is moderately soluble in water and in alcohol, but only slightly so in ether. It does not crystallise from its alcoholic solution, but separates, on evaporation, as a resinous mass; when, however, the solution is mixed with water, it is gradually deposited in a crystalline form, on evaporation. Boiled with caustic potash, baryta water, or hydrochloric acid, glycocholic acid undergoes decompositions similar to taurocholic acid—cholic acid, or choloidic acid being formed, and glycocoll separated.

Glycocoll ($C_4 H_5 N O_4$), (glycocine, sugar of gelatine) may be artificially obtained from gelatine by the action of mineral acids and also from hippuric acid, which may be considered as a conjugate of benzonic acid with glycocoll, by boiling the hippuric acid with hydrochloric acid. It forms colourless rhombic prisms (Funke, *Plate III. Fig.* 5), which are hard and unchangeable in the air, and have a taste almost as sweet as that of cane-sugar. It contains nitrogen, but no sulphur.

All biliary acids, the conjugate, as well as cholic and choloidinic acids, exhibit peculiar and very characteristic reactions with sulphuric acid and sugar, the reactions depending upon the presence of pigment-matters, as well as upon the taurine and glycocoll. When, for example, a few drops of a solution of sugar are mixed with a watery solution of any biliary acid, and concentrated sulphuric acid added, until the mixture is heated to 50° to 70° C., (122° to 158° Fahr.) the mixture assumes a beautiful, purple-violet colour.

The following is another and very sensitive test: The biliary acid or its salt is treated with a small quantity of concentrated sulphuric ad, slightly warmed, and then water added to it. The resinous akes which separate are removed from the acid, and slightly washed ith water, but so as not to remove the whole of the sulphuric acid, nd then gently heated in a basin until the colours appear. The esidue is then exhausted with a very little spirits of wine, and the reen solution evaporated, and kept stirred during the process; the nner side of the vessel thereupon becomes covered with a deep [illegible]-coloured coating, even though only a very small quantity of he acid is present. If foreign matters be mixed with the biliary cid, or if the action of the sulphuric acid be too long continued, r the process be conducted at too high a temperature, the pigmentary coating will be of a green colour.

Tests.—A quantity of urine (300 to 500 C.C.) is evaporated nearly to dryness in a water-bath, and the residue extracted with ordinary alcohol; the spirituous solution is then evaporated, and the residue extracted with absolute alcohol. The solution thus obtained, containing only a small quantity of salts, is freed from spirits of wine, the residue dissolved in a little water, the solution treated with acetate of lead, the precipitate collected after twelve hours standing, and washed and dried between folds of bibulous paper. To separate, as far as possible, the other substances which are thrown down with the lead-precipitate, the bile salt of lead is extracted with boiling spirits of wine, carbonate of soda added and the solution evaporated to dryness; the residue is then treated with absolute alcohol in order to procure the bile-salt of soda.

The salt of soda, thus obtained, always contains a small quantity of a resinous constituent of the urine mixed with the bile-acids; this resinous body becomes of a brownish-red under the action of sulphuric acid, at times also of a lightish blue or violet, and when heated with addition of a little sugar, of a reddish or yellowish-brown. This coloration is rarely powerful enough to conceal the biliary reaction; but if it should be found on trial to do so, the bile-acid must be once more precipitated from the watery solution with acetate of lead, the precipitate collected after standing awhile and then decomposed, as above described, with carbonate of soda. Two or three drops of sugar-solution (1 part sugar to 4 parts water) are added to the watery solution of the soda-compound, which is concentrated as much as possible, and then pure concentrated sulphuric acid, free from sulphurous acid. Care must be taken that the temperature does not exceed 70° C. (158° Fahr.) If any bile-acid be now present, the fluid will first of all become muddy, then clear, and at the same time yellow, soon afterwards of a pale cherry, dark carmine-red, and lastly of a beautiful purple-violet colour.

The reaction becomes much more sensitive, when the soda-solution is evaporated to a few drops in a porcelain cup, a few drops of pure dilute sulphuric acid (4 parts $HO + 1$ part SO_3HO), and a trace of sugar-solution added to it, and the mixture then carefully evaporated at a very gentle heat over a small lamp. The reaction was beautifully marked when only $\frac{6}{100}$ of a milligramme of bile-acid was present. (Neukomm). This modified process is far superior to the original one of Pettenkofer. We cannot be certain that bile-acid is present unless the fluid assumes a distinct *purple-violet*, as well as a red colour.

Cholesterine has been occasionally found in the urine, mingled with other fats in cases of fatty degeneration of the kidneys. The sediment, which consisted chiefly of fat cells, after being collected and dried in a water-bath, was digested with a mixture of alcohol and ether. The extract, when filtered and concentrated, deposited a considerable quantity of crystals of cholesterine, which, by their microscopic characters, cannot be readily mistaken for any other substance. (Funke, *Plate VI. Fig.* 1.)

SECTION XXVI.

LACTIC ACID.

Composition :—

In 100 parts :	Carbon	40·000
	Hydrogen . . .	5·555
	Oxygen	44·445
	Water	10·000
		100·000

Formula: $C_6 H_5 O_5 + H O$. Atomic weight of anhydrous acid $= 81$.

A. *Occurrence.*—Lactic acid is found in most of the animal fluids, and particularly (under normal conditions) in the juice of muscles, and in the juices of the stomach and intestines. It is also sometimes found in the blood, in the saliva, in sour milk, or milk which has been altered by disease, in the fluids of flesh, &c. It does not exist normally in the urine, but always appears in it when large [illegible] into the blood, as happens, for [illegible] which gives rise to [illegible]. Lactic acid has also been found in the [illegible] disturbances of the [illegible] use in febrile [illegible] lactic acid in [illegible]

[illegible] present in the urine [illegible]. Lactic acid is also [illegible] matters— [illegible]; [illegible] employed in testing for [illegible]

[illegible] lactic [illegible] either [illegible] crystalline form. [illegible] water from the [illegible] and at a [illegible] acid, and [illegible]

[illegible] microscopic [illegible] consequently [illegible] acid.

[illegible] carbonate of lime [illegible] it is seen to [illegible] the shorter styles [illegible]. Funke, *Plate* [illegible]

2. [illegible] of zinc with lactic acid. [illegible] under the microscope [illegible] may be easily [illegible] of a solution of lactate [illegible] the first crystals [illegible]. These crystals then [illegible] becoming thinner, and their [illegible]. This peculiar bellied-, barrelled-, or club-shaped form is very characteristic of lactate of zinc. (Funke, [illegible]

Tests.—The presence of lactic acid in the urine cannot be satisfactorily demonstrated, unless it be obtained nearly pure; and even then it exhibits, as lactic acid, no distinguishing characteristic. Consequently, we must learn its nature by elementary analysis, by ascertaining its atomic weight, and by the study of its salts. As, however, in testing for lactic acid we very rarely obtain materials sufficient for the first two kinds of experiments, we make use of the zinc-salt, which crystallises readily, and in a very characteristic form. The following is the method employed for this purpose:—Fresh urine is evaporated nearly to dryness in a water-bath, and the residue then treated with an alcoholic solution of oxalic acid. The oxalate which is thus formed, as well as the oxalate of urea, remain undissolved, the lactic acid, together with phosphoric and hydrochloric acids, remaining in solution. The fluid is then digested with hydrated oxide of lead, evaporated to dryness, and the residue extracted with absolute alcohol, which dissolves the lactate of lead. The filtrate is treated with sulphuretted hydrogen, and after filtration evaporated in a water-bath to a syrup; the syrup is then shaken up with ether, which, on evaporation, leaves the lactic acid more or less pure. This is then dissolved in a little water, boiled with oxide of zinc, filtered, and allowed to crystallise slowly on the object-glass. The presence of the lactic acid is readily recognised by the barrel- and club-shaped form of the crystals, and especially by their peculiar mode of enlargement.

Scherer uses the following process, which is in every respect an excellent one, in testing for lactic acid:—The extract containing the lactic acid is dissolved in water, the solution precipitated with baryta and filtered. Any volatile acids which may be present in the filtrate are separated by distillation with a little sulphuric acid; and the residue is then left to digest several days in strong alcohol. The acid fluid is evaporated to dryness with a little milk of lime, the residue dissolved in boiling water, and filtered while warm, to separate any superfluous lime and sulphate of lime. A stream of carbonic acid is then passed through the filtrate, which is once again heated to boiling; the precipitated carbonate of lime is separated by filtration, the fluid evaporated to dryness, and the residue treated with strong alcohol, filtered if necessary, and the neutral filtrate left for several days to deposit the lactate of lime. If the lactic acid is present in too small quantity to produce crystals, the solution must be evaporated to a syrup, mixed with strong alcohol, and allowed to stand; a darkish deposit, consisting of extractive matter and lime, is then usually formed. The fluid part is now poured off into a closed vessel, and a small quantity of ether gradually added to it. Even mere traces of lactate of lime, whose presence may be easily recognised under the microscope, will hereby be separated from the fluid.

If there is plenty of material to operate upon, the following method, proposed by Lehmann, for the preparation of several salts, may be adopted (Lehmann, *Physiolog. Chemie*, Vol. 1, p. 99). The lactic acid, prepared as above described, is saturated with a solution of baryta, the excess of baryta removed by a stream of carbonic acid gas, the solution filtered, the filtrate evaporated to the consistence of syrup, treated with alcohol, again evaporated and allowed to stand. The syrup is then poured off, and separated from the foreign crystals which are formed, dissolved in water, and decomposed with a solution of gypsum. In this way lactate of lime and sulphate of baryta are formed. The sulphate of baryta is separated by filtration, and the filtrate then allowed to crystallise, when the double brush-like forms of lactate of lime are easily recognised, together with crystals of gypsum.

The whole of the lactate of lime is now dissolved in strong alcohol and decomposed, without previous filtration, with sulphate of copper. Any excess of the copper-salt, as well as of the gypsum which is formed and which is also insoluble in alcohol, is separated by filtration; and a little of the solution of lactate of copper, then allowed to crystallise under the microscope. The remaining fluid is highly concentrated by boiling, and a stick of zinc introduced into it; if lactic acid be present, the zinc in a short time is covered with white crystals of lactate of zinc, which are also to be subjected to microscopic examination. Lastly, the solution of the salt of zinc may be precipitated by protochloride of tin. The salt of tin thus obtained is found to consist of grandular masses of crystals, forming groups of thick rhombic tablets lying one over the other.

As already said, we rarely have sufficient materials to enable us to follow out the whole of this complicated process; consequently, we must be satisfied with the preparation of the lactate of lime after the manner first described. It is useful, however, to practise these processes, in order to learn the different crystalline forms of the salts of lactic acid. It should always be remembered that artificially-formed lactic acid yields crystals different from those which are obtained from animal fluids; consequently, only the latter kind should be operated upon.

SECTION XXVII.

ACETIC ACID.

Composition:—

In 100 parts:	Carbon . . .	40·00
	Hydrogen . . .	6·67
	Oxygen . . .	53·33
		100·00

Formula: $C_4 H_3 O_3 + H O$.

A. *Occurrence.*—Acetic acid appears in stale urine, in which the fermentation process has already commenced. It also forms, in large quantity, during the fermentation of diabetic urine. Moreover, it has been found in the fluids of muscle and of the spleen, in leucocythemic blood, in the gastric juices in cases of severe dyspepsia, and in the sweat. It is a product of the decomposition of many animal substances, and may be formed, for instance, from the action of powerful oxidising agents upon proteine bodies, gelatine, &c.

B. *Chemical Characters.*—Acetic acid, in its concentrated form, is a colourless liquid, having a durable sour odour, and a sharp pungent taste. It boils at 120° C. (248° Fahr.), crystallises at C. 5° (41° Fahr.), and above 16° C. (60° Fahr.) becomes fluid.

1. Perchloride of iron, added to a solution of a salt of acetic acid, produces the deep-red colour of per-acetate of iron.

2. Nitrate of silver in a neutral solution of a salt of acetic acid throws down a white crystalline precipitate of acetate of silver, which dissolves in boiling water without reduction, and crystallises out of it as the liquid cools. This salt contains 69·4 per cent. of oxide of silver.

3. The characteristic odour of acetic ether presents itself when a salt of acetic acid is treated with alcohol and sulphuric acid. Treated with sulphuric acid alone, the salt gives off the pungent odour of acetic acid.

C. *Tests.*—Two to three litres of urine are neutralised with a solution of soda, provided the urine is not already alkaline, and the mixture evaporated on the open fire to a fourth or a sixth of its volume. Tartaric or phosphoric acid is then added to the residue, which is subjected to distillation, and the distillation continued, until the distillate has no longer an acid reaction. The distillate is then saturated with carbonate of soda, evaporated to dryness, and again distilled with sulphuric acid. The acid fluid thus obtained is neutralised with carbonate of soda, and, as it crystallises, acetate of soda is separated in the form of white prisms and needles. Butyric acid may be found in the mother liquor.

The analysis of the salts of silver and baryta give decisive results.

Crystallised acetate of soda contains 22·9 per cent. of soda, the baryta-salt 60 per cent. of baryta, the silver-salt 69·4 per cent. of oxide of silver, and 64·67 per cent. of silver.

SECTION XXVIII.

BUTYRIC ACID.

Composition :—

In 100 parts :	Carbon	54·545
	Hydrogen	7·955
	Oxygen	27·273
	Water	10·227
		100·000

Formula: $C_8 H_7 O_3 + H O$. Atomic weight of the anhydrous acid 79. Its saturating capacity 10·126.

A. *Occurrence.*—Butyric acid exists ready formed in butter in combination with oxide of glycerine; it is set free in rancid butter, and is in fact the source of its disagreeable odour. It is also found in several of the animal fluids and secretions, in the sweat for example, in the secretions of the external genital organs, in the juice of muscle, and occasionally also in the gastric juice. According to Berzelius, free butyric acid is constantly present in the urine; but the fact has not yet been satisfactorily proved. It is, however, sometimes, though rarely, found both in healthy and in unhealthy urine, from which we may conclude that its presence there is not connected with any special form of disease. Lehmann occasionally found butyric acid in the urine of pregnant women, but he also often met with it in the urine of men, and of women not pregnant.

A considerable quantity of butyric acid is formed, when diabetic urine is treated with powdered chalk, and the mixture allowed to ferment at a temperature of 35° to 40° C. (95° to 104° Fahr.) (Scherer, *Brieflch. Mitth.*); but at a lower temperature, and without the addition of chalk, acetic acid only is not unfrequently formed.

B. *Chemical Characters.*—Anhydrous butyric acid is a colourless and very mobile fluid; it refracts light strongly, and has a powerful odour. As a hydrate it forms an oily and exceedingly repulsive liquid, having an odour of rancid butter, and a pungent acid taste. It is soluble, in all proportions, in water, alcohol, and ether. Most of its salts are also soluble in alcohol and water, and give off the repulsive odour of butyric acid on the addition of mineral acids.

1. Butyric acid unites with alkalies, alkaline earths, and the metallic oxides proper. The compounds which it forms with the alkalies are deliquescent and uncrystallisable. Its other salts, on the other hand, crystallise readily.

a. *Butyrate of baryta* is prepared by saturating butyric acid with baryta-water. When the crystallisation of this solution is rapidly effected, the compound separates in the form of glistening fatty scales on the surface of the fluid. These scales, examined under the microscope, appear as dense groups of ill-defined crystalline scales; but when the solution of butyrate of baryta is allowed to evaporate spontaneously, long, flattened, and perfectly transparent prisms, mostly grouped together in stellate glands, are formed. The salt readily dissolves in water, and its solution reddens litmus paper. (Funke, *Plate I. Fig.* 3.) Butyrate of baryta contains 49·23 per cent. of baryta.

b. *Butyrate of lime* readily dissolves in cold water, but nearly the whole of it separates again when the solution is boiled. It crystallises in fine needles, has an odour of butyric acid, and yields, on dry distillation, butyrone and butyral.

c. *Butyrates of the metallic oxides* are formed by the precipitation of a concentrated solution of an alkaline butyrate, by means of a solution of the corresponding metallic salt. Nitrate of silver, in this way, yields a yellowish-white crystalline precipitate of butyrate of silver, which is wholly insoluble in cold water, and contains [illegible] of oxide of [illegible] a precipitate, [illegible] of mercury, [illegible] precipitate of [illegible] as it cools [illegible]

[illegible] sulphuric acid, [illegible] peculiar and [illegible]

[illegible] existence [illegible] have of it [illegible] we have to [illegible] crystallisa- [illegible]

[illegible] the [illegible] filtration [illegible] considerable [illegible] residue with sul- [illegible]

[illegible] this process, [illegible] describes, how- [illegible] of the [illegible] an acid [illegible] strongly of [illegible] of the acid. [illegible] with sulphuric [illegible]

[illegible]

[illegible]

[illegible]	[illegible]·85
[illegible]	4·92
[illegible]	26·23
	100·00

[illegible]

[illegible]—Benzoic acid is probably present in the urine of orous animals when overworked or underfed. It is constantly in putrefying urine, both of man and herbivorous animals, formed through the decomposition of the hippurates. Benzoic is the non-nitrogenous conjugate of hippuric acid, for, as we already seen, benzoic acid within the body takes up the nts of glycocine, and then appears in the urine in the form of ric acid. And, on the other hand, hippuric acid, when placed ntact with decomposing matters, is immediately decomposed benzoic acid and glycocine. Benzoic acid, again, appears as roduct of the decomposition of various animal substances, and ularly of proteine-bodies, of gelatine, &c.

Microscopic characters.—Benzoic acid, when sublimed, appears e form of fine, colourless, glistening needles and scales, and, prepared in the moist way, in the form of scales, small columns, -sided needles, whose primary form is a right rhombic prism. als obtained through the cooling of its aqueous solutions always r under the microscope as tables of exactly 90° C. (194°), arranged in rows, or overlapping each other; sometimes, but ften, one of the angles is truncated, but always so as to give th the angles 135° C. (275° Fahr.). (Funke, *Plate I. Fig.* 6.)

Chemical characters.—Benzoic acid sublimes at 240° C. ° Fahr.), without decomposition; its vapour causes an irrita- f the throat, and excites coughing. It is but little soluble in but much more soluble in hot water; alcohol and ether dis- it pretty readily. Its solutions redden litmus.

Most of the salts of benzoic acid are soluble in water, those which it forms with the heavy metallic oxides are difficult of ion. The alkaline benzoates are soluble in alcohol.

Strong acids decompose the solutions of the benzoates, the oic acid being separated in the form of white shining scales.

Perchloride of iron throws down from solutions of alkaline ben- s a brownish-yellow precipitate of benzoate of iron, which is nposed by the action of ammonia into oxide of iron and ben- of ammonia. Treated with a little hydrochloric acid, the benzoate n dissolves with separation of the benzoic acid.

Tests.—Alkaline urine is evaporated to the consistence of an ct, which is then treated with alcohol. From this alcoholic ct benzoic acid is separated in a distinctly crystalline form on ddition of a stronger acid. If the quantity is too small to yield ls in this way, the mass must be extracted with ether, and the solution allowed to evaporate spontaneously. From this ethereal extract the benzoic acid is separated in a crystalline form on the addition of water. The crystals may then be examined microscopically and chemically.

If, again, putrefying urine be treated according to the process given for the testing of acetic acid (see Sect. xxvii.), we shall find, at the end of the second distillation, and especially when this has been pushed a little far, that white scales and plates appear; these remain for the most part in the condenser, and are readily recognised as benzoic acid. To distinguish benzoic from hippuric acid, see Section VII. E. 1, 2, and 3.

SECTION XXX.

FAT.

A. *Occurrence.*—Fat is not often met with in the urine. The peculiar milky-looking urine (*urina chylosa*) occasionally met with does not owe its turbidity and colour to fatty particles suspended in it, but, as Lehmann states, to the presence of pus-corpuscles. Dr. Beale, however, speaks of a milky urine, containing much fat, which was during some months passed in the morning by a woman of fifty years of age. On the addition of ether the urine became perfectly clear. Quantitative analysis gave 13·9 grammes of fat in 1000 parts. Dr. Beale considers that the chylous character of the urine results from a separation of the chyle through the kidneys. He also found cholesterine in the fat-cells passed with the urine in fatty degeneration of the kidneys; this cholesterine dissolved in other fats could only be obtained by extraction with alcohol and subsequent crystallisation.

Fatty globules are, however, often found in the urine of persons suffering from diseases which are attended with a rapid wasting of the body.

B. *Microscopic characters.*—Fat in its free state is readily recognised under the microscope. Fat-globules present the form of flattened discs; they possess an extraordinary power of refracting light, whereby they obtain a dark and somewhat irregular contour. Single globules are often seen under the microscope to run one into the other, and by this they may be distinguished from fat vesicles, hich are completely spherical. Fat-cells have a smooth and oundish form, but when exposed to pressure occasionally assume a olyhedral shape. Their surfaces also possess a strong refractive ower; with transmitted light their contour is sharp and dark, but ith reflected light their borders have a shining silvery appearance, nd their centre appears whitish. These cells are easily burst by ressure, their contents escaping, and their surface assuming a more r less wrinkled appearance. (Funke, *Plate VII. Figs.* 3 & 4.)

c. *Tests.*—As fat is very rarely met with in the urine, and only n exceedingly small quantity, it is not possible to determine its articular kind by tests. We must therefore be satisfied with ecognising the presence of the fat as such. The microscopic haracters of fat are so peculiar and distinctive that any one who has ver seen a fat-globule will not fail to recognise it again. Conseuently, we always, in the first instance, test its presence with the nicroscope. If we fail to discover it by that means, we then evapoate a portion of the urine to dryness in a water-bath, expose the esidue for some time to a temperature of 110° C. (230° Fahr.), nd then pour over it small quantities of ether so long as the ether ontinues to dissolve any of it. This ethereal solution will take up ll the fat, and when evaporated—an operation which is best perormed in a test-glass—leaves the fat as a residue. This residue nay then be examined under the microscope, and if there be enough f it, by chemical agents. The production by it of grease-spots on ine paper, as well as its properties when heated (the development of crolein), prevent fat being mistaken for any other body.

SECTION XXXI.

SULPHURETTED HYDROGEN.

Sulphuretted hydrogen is sometimes, though very rarely, found in he urine. Its presence is readily ascertained by its property of lackening paper moistened with a solution of sugar of lead. The xperiment is thus best performed:—a small glass is filled half-full with the urine to be tested for the sulphuretted hydrogen, and overed with a watch-glass, to the bottom of which a little bit of he lead-paper has been attached by means of a drop of water.

This paper becomes brown or black (and more readily if the urine be gently heated), according to the amount of sulphuretted hydrogen which is present. Sulphuretted hydrogen, moreover, may always be easily recognised through its odour of rotten eggs. I had once an opportunity of examining for a length of time urine which contained sulphuretted hydrogen; it was periodically secreted by a man whose lower extremities were paralysed through gout. The urine, when it contained sulphuretted hydrogen was slightly acid, of a bright yellow colour, usually threw down a sediment, and immediately blackened a piece of lead-test paper when held over it.

It has been already stated, under the head of sulphuric acid (Sect. XIII. B. 3), that sulphates, when exposed to a moderately high temperature in contact with organic substances, soon give rise to the formation of sulphuretted hydrogen; and in this way we may perhaps account for its formation in the urine. Sulphuretted hydrogen may also be formed in the urine from the decomposition of animal substances contained in it, and quite independently of the sulphates. Urine, for example, which contains albumen, will often in a short space of time show, by its odour, the presence of sulphuretted hydrogen; this fact I have frequently noticed.

There are some other substances, such as allantoine, leucine, and tyrosine, yet to be considered. They are very rarely found in human urine, but occasionally appear in it under pathological conditions. Oxalic acid, which is frequently present in the urine, and cystine, are chiefly found in the sediment of urine; I shall, therefore, speak of them under that head.

SECTION XXXII.

ALLANTOINE.

Composition:—

In 100 parts:		
	Carbon . . .	30·38
	Hydrogen . . .	3·16
	Nitrogen . . .	35·44
	Oxygen . . .	25·32
	Water	5·70
		100·00

Formula: $C_8 H_5 N_4 O_5 + H O$.

A. *Occurrence.*—Allantoine is found in the allantoic fluid of the cow, and in the urine of calves as long as they suck or are fed on milk. Städeler found it in the urine of a dog whose respiration was impeded; Köhler found it in the urine of rabbits after the injection of oil into the lungs (compare *Uric Acid*, VI. A.); and Schottin met with it in the urine of man, after the ingestion of a large quantity of tannic acid. Allantoine may also be obtained by treating uric acid with peroxide of lead (Sect. VI. D. 3.), ferricyanide of potassium and permanganate of potash. (Sect. VI. D. 4.)

B. *Preparation.*—Uric acid is stirred with water into a thinnish paste, and heated to boiling; peroxide of lead is then added in small quantities, as long as it (the peroxide) continues to lose its brown colour. Allantoine separates from the filtrate, as it cools, in beautiful crystals, and urea is left in solution in the mother-liquid.

C. *Microscopical Characters.*—Allantoine appears under the microscope in the form of colourless prismatic crystals, clear as water and lustrous as glass; their primitive form is the rhombohedric. The crystals, when separated from concentrated solutions, form stellate glandular masses. (Funke, *Plate V. Fig.* 4.)

D. *Chemical Characters.*—Allantoine is tasteless; it has no action on vegetable colours, is soluble in 160 parts of cold, and in a less quantity of boiling water. It is also dissolved by boiling alcohol, but in great part separates again as the alcohol cools. It is insoluble in ether.

1. Concentrated alkalies convert allantoine, by absorption of water, into oxalic acid and ammonia.

2. By the action of boiling nitric acid it is decomposed into urea and allantoic acid ($C_6H_4N_2O_6$).

3. Nitrate of silver and ammonia added to a saturated solution of allantoine, throw down a white flocculent precipitate of allantoine-oxide of siver, which is found under the microscope to consist of clear and perfectly spherical particles.

4. Corrosive sublimate causes no precipitate in a solution of allantoine; but, as in the case of urea, a precipitate is thrown down in it by a solution of nitrate of mercury.

5. Mixed with yeast and exposed to a temperature of 30° C. (86° Fahr.), allantoine is decomposed into urea, and oxalate and carbonate of ammonia. At the same time there is generated a syrupy acid, probably identical with another acid, also syrupy, which I met with, together with allantoine and urea, in treating uric acid with permanganate of potash.

E. *Tests.*—To ascertain the presence of allantoine in the urine, the urine is precipitated with acetate of lead, filtered, and any excess of lead removed by sulphuretted hydrogen. The filtered solution is evaporated to dryness in a water-bath, and the residue exhausted with boiling dilute spirits of wine. When the filtrate, which is, of course, concentrated by evaporation, cools, crystals are separated, if any allantoine is present; these, when recrystallised out of boiling water, serve for testing. In addition to the microscopic forms of pure allantoine, we have also the peculiar globular forms characteristic of allantoine-oxide of silver. (D. 3.)

According to Lehmann, we may also separate the allantoine by precipitation with nitrate of mercury. The urine is thoroughly precipitated with a mixture of nitrate of baryta and caustic baryta; the filtrate, carefully neutralised with nitric acid, is concentrated in a water-bath, and then treated with a solution of nitrate of mercury in slight excess. The precipitate which is formed, consisting of urea and allantoine-oxide of mercury, is collected on a filter and washed, suspended in water, and decomposed with sulphuretted hydrogen. The solution filtered off from the sulphide of mercury is strongly concentrated in a water-bath, and left for several days to crystallise. Any urea accidentally crystallised with the allantoine may be removed by cold alcohol. The allantoine which remains should then be once more crystallised out of boiling water, before being made use of for the microscopic test, or for the preparation of the characteristic silver-compound.

The urine of young calves is evaporated to a syrupy consistence in a water-bath, and allowed to stand for several days. The crystals that separate are washed with water, and then boiled with a little water. The solution is decolorised with animal charcoal, and filtered while hot; a few drops of hydrochloric acid are added to prevent the separation of phosphate of magnesia, and it is left to cool; the allantoine then separates in the form of thin crystals united together in bundles.

Calf's urine is strongly acid, differing, in this respect, from the urine of the grown-up animal, which has ceased to feed upon milk. It contains as much urea and uric acid as the urine of man, but no hippuric acid. On the other hand, the urine of the cow, which is rich in hippuric acid, contains no allantoine.

SECTION XXXIII.

LEUCINE.

Composition :—

In 100 parts :	Carbon	54·96
	Hydrogen	9·92
	Nitrogen	10·68
	Oxygen	24·44
		100·00

Formula : $C_{12}H_{13}NO_4$.

A. *Occurrence.*—Leucine was originally obtained as a product of decomposition of highly nitrogenous animal substances, when undergoing putrefaction or subjected to the action of strong acids and alkalies. It has, however, of late been recognised by Virchow, Frerichs, Gorup-Besanez, Städeler, and others, as both a normal and pathological constituent of various organs and juices of the body, both in man and beast, being usually found associated with tyrosine. Leucine has, in fact, been found in the liver, especially when the function of the organ had been deranged; and, together with tyrosine, in the pancreas and the pancreatic juice in considerable quantity; also in the spleen, in the upper part of the intestinal canal, in the thymus, the thyroid and salivary glands, in the saliva, in the lymphatic glands, the lungs, and the brain. Leucine has also been found in the urine in the course of certain diseases—in typhus, in small-pox, and in atrophy of the liver.

B. *Microscopical Characters.*—Impure leucine, as obtained on its first separation from animal fluids, crystallises in granular masses, consisting of roundish, and in part concentrically striped globules, mostly of a yellowish colour, some of them finely pointed, but without any distinct crystalline form, they somewhat resemble globular fat-cells. When pure, it separates in gland-like masses of leaves or scales, whose contour is often difficult of determination. Single borders are frequently seen like sharp dark lines, so that on the first glance several crystals appear as capillary needles terminating in two points. (Funke, *Plate III. Fig.* 6.)

C. *Chemical Characters.*—1. Pure leucine takes the form of white crystalline scales, has a fatty feel, and is without taste or smell. It is not readily moistened with water, but is nevertheless tolerably soluble in it; it is less soluble in alcohol, and quite insoluble in ether. It readily dissolves in acids and alkalies.

2. Leucine, carefully heated to 170° C. (338° Fahr.) in a glass tube open at both ends, sublimes, without previous fusion, in white flocculent masses, which, like oxide of zinc, are in part conveyed along the tube by the heated current and escape into the air around. This peculiar mode of sublimation is very characteristic of leucine. Heated to 180° C. (356° Fahr.) leucine fuses, and is decomposed into carbonic acid and amylamine:

$$\begin{array}{ll} \text{2 Carbonic Acid} = & C_2\,O_4 \\ \text{1 Amylamine} = & N\left\{\begin{array}{l} C_{10}\,H_{11} \\ H \\ H \end{array}\right. \\ \text{1 Eq. Leucine} = & C_{12}\,H_{13}\,N\,O_4. \end{array}$$

3. It is separated in beautiful glistening scales from a boiling mixture of leucine and sugar of lead, when ammonia is carefully added, as leucine-oxide of lead.

4. A solution of nitrate of mercury does not cause a precipitate in an absolutely pure solution of leucine. Any precipitate thereby formed indicates the presence of tyrosine—*i. e.*, if the supernatant fluid has a reddish or a rosy-red colour.

5. Leucine, when mixed with putrefying animal matters, and also when fused with hydrate of potass, is converted into valerianic acid ($C_{10}\,H_{10}\,O_4$)—carbonic acid, ammonia, and hydrogen, being at the same time evolved.

6. Pure leucine, carefully evaporated with nitric acid on platina foil, leaves a colourless and nearly imperceptible residue. If to this residue a few drops of caustic soda are added, and heat is applied, the leucine will be dissolved; the solution will be perfectly clear, or more or less discoloured, according to its degree of purity. Again, if the fluid be carefully concentrated on platina foil over a lamp, it will in a short time be gradually condensed into an oily sort of drop, which rolls about on the foil, neither moistening nor adhering to it. This property is very characteristic even of leucine which is not perfectly pure. (Scherer.)

SECTION XXXIV.

TYROSINE.

ition :—

In 100 parts:	Carbon	59·67
	Hydrogen	6·08
	Nitrogen	7·73
	Oxygen	26·52
		100·00

nula : $C_{18}H_{11}NO_6$.

ccurrence.—Tyrosine is formed in exactly the same way as
, and is produced either somewhat later, or, more generally, at
e time as the leucine, during the decomposition of highly-
nous animal matters. Like leucine, it is also found normally
thologically in the human body; Frerichs has found it, to-
with leucine, in large quantities in the urine of patients suffer-
m typhus, small-pox, and acute atrophy of the liver.

icroscopical Characters.—Tyrosine forms a snow-white, silky,
ng, adhesive mass, which consists of long shining needles
ed together; these needles again are composed of very delicate
needles, grouped together in a stellate form. Tyrosine often
lises out of an ammoniacal solution, in globular masses,
are composed of a number of fine needles congregated to-
in a radiating form, and jagged at the periphery, in conse-
of small spear-shaped crystals projecting from them. Com-
under the object-glass, these little globules of tyrosine break
into fragments, consisting of extremely fine white needles.
r.)

hemical Characters.—Tyrosine has neither taste nor smell;
nost insoluble in cold water, but readily dissolves in boiling
and still more readily in acids and alkalies; it is insoluble in
and ether.

Vhen treated it emits the odour of burnt horn; it does not
o sublimation.

itric acid carefully evaporated with tyrosine produces, in
n to oxalic acid, a yellow body—nitrate of nitrotyrosine; this
, when treated with potash or ammonia, assumes a deep
-brown colour. Tyrosine, evaporated on platinum foil with

[illegible] dissolves rapidly, and assumes a lively [illegible] as soon as the acid becomes warm. [illegible] translucent residue of a deep [illegible] this residue a few drops of hydrochloric [illegible] a deep yellow-red colour, and when [illegible] brownish-black residue. Scherer prefers [illegible] on account of its easy performance. (4.) [illegible] down from a boiling solution of [illegible] separate, the supernatant liquid taking an [illegible] This test is exceedingly sensitive. If [illegible] it must be boiled and left at [illegible] will not take place.

[illegible] basin with a few drops of concentrated [illegible] heated, dissolves, and assumes a [illegible] dilution with water, the acid is [illegible] of baryta, the mixture boiled to [illegible] baryta, and a neutral dilute solution [illegible] the filtrate, a beautiful violet colour [illegible] quantity of leucine may be present with [illegible] is very delicate. When diluted 6000 [illegible] red in a common test tube. [illegible] inches thick, a distinct rosy-red [illegible] dilution is carried to 25,000, and [illegible] when the dilution reaches even [illegible]

[illegible].—A mixture of 5 pounds of oil of vitriol, and 13 pounds of water, is poured upon 2 pounds of horn-shavings, and the mixture boiled for twenty-four hours, the water as it evaporates being renewed. The sulphuric acid is then removed by milk of lime, filtered, washed with boiling water, and the filtrate, after the solution has been reduced to about 12 pounds, freed from the dissolved lime by the careful addition of oxalic acid. The filtrate is now evaporated until a crystalline pellicle begins to form on its surface. The globular-like masses of crystals found in it are leucine, mixed with varying quantities of tyrosine; for it rarely happens that tyrosine is altogether absent.

The different degree of solubility of these two bodies in water is made use of for the purpose of separating them. The crystalline compound is dissolved in a large quantity of boiling water, so that only a small portion of the crystals separates when the solution cools; these crystals are white needles of the nearly insoluble tyrosine. The leucine may now be obtained from the mother-liquor in white crystalline masses, after treatment with animal charcoal and further concentration.—(Schwanert, *Ueber Leucin; Dissert., Göttingen*, 1857.)

E. *Tests.*—Leucine and tyrosine have not yet been found in the urine of healthy people. Frerichs first discovered them in the urine of patients suffering from typhus. In acute atrophy of the liver, leucine and tyrosine are present in large quantities, whilst, at the same time, only traces of the substances such as urea, &c., which normally represent the final products of the metamorphoses of the tissues, are found in the urine. Urine of this kind often deposits spontaneously a softish greenish-yellow sediment, consisting of round grandular masses of needles of tyrosine; and when evaporated on an object-glass, leaves numerous crystals of leucine and tyrosine. In order to obtain a large quantity of these bodies, Frerichs drew off the urine, which also distinctly showed the presence of bile-pigment, with a catheter, freed it from colouring and extractive matters by precipitation with basic acetate of lead, filtered, separated the superfluous lead by sulphuretted hydrogen, and then concentrated the clear filtrate. In twenty-four hours a quantity of tyrosine,* sufficient for several analyses, was deposited.†

Schmeisser, by the same process, found a large quantity of tyrosine in the urine, in a case of acute yellow atrophy of the liver. The urine was free from albumen, and by none of the known tests could the presence of bile-pigment be discovered in it. The tyrosine contained in it was crystallised out of boiling water, and then subjected to chemical and microscopical tests. To obtain the leucine, the evaporated residue is first of all treated with cold absolute alcohol as long as the alcohol dissolves anything out of it, and then extracted with boiling alcohol of ordinary strength; in this way a darkish-brown, tenacious substance is obtained, readily soluble in water, and containing the remains of the tyrosine. The alcoholic solution last obtained, after evaporation and long-standing of the syrupy residue, deposits the leucine in it in the globular form described above (Sec. XXXIII. B.), which may be subjected to chemical and microscopical tests.

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* Together with the tyrosine, another crystallisable body of a similar form, but richer in nitrogen—8·83 per cent.—was found.

† Frerichs, *Deutsche Klinik*, 1855. *N.* 31, *p.* 343.

It is better, however, before testing to purify still further the leucine thus obtained. For this purpose we may make use of the compound formed by it with oxide of lead. The watery solution of leucine, freed as far as possible from the mother-ley by pressure between paper, is rendered strongly alkaline with ammonia, and then precipitated with sugar of lead solution, or basic acetate of lead as long as any precipitate forms. The precipitated leucine-oxide of lead is collected on a filter, slightly washed, then suspended in water, and decomposed with sulphuretted hydrogen. The leucine will now be separated in a pure crystalline form from the filtrate on its evaporation. (Lehmann.) If the urine contains albumen, the albumen must be previously separated by heat and filtration, and the filtrate then tested for leucine and tyrosine.

Care must be taken in this experiment that the urine is used fresh; because leucine in contact with putrefying animal substances is very readily decomposed, and valerianic acid formed.

The urine described by Frerichs as obtained in the case of acute atrophy of the liver, contained 4·9 per cent. of solid residue, and 0·14 per cent. of ash. The residue was strongly acid, and no urea could be obtained from it. It contained, besides leucine and tyrosine, a tenacious, extractive-like substance, similar to that which is formed (together with tyrosine and leucine) during the artificial decomposition of proteine-bodies by acids. The ash consists mainly of chlorine-compounds and sulphates. It is remarkable that alkaline and earthy phosphates are entirely absent. (Frerichs.)

SEDIMENTS OF THE URINE.

SECTION XXXV.

We have already considered (see Sec. I.) the peculiar decompositions which healthy urine undergoes when left at rest for some time. These changes, which we have distinguished by the names of acid and alkaline fermentations, have a very intimate connexion with the formation and separation of its sediments.

We will, first of all, consider the sediment which is most frequently met with in the urine—*urate of soda*. We often notice that urine, which is perfectly clear when passed, separates this sediment shortly afterwards. In such case we may conclude, that the urate of soda is increased to such an extent in the urine that it cannot remain in solution at ordinary temperatures. This view is confirmed by the circumstance that the sediment is usually redissolved when a less concentrated urine is added to it, or when it is heated.

It often happens, however, that the urine remains clear long after it has attained the same temperature as the surrounding air, and that the separation of sediment does not take place for twelve or twenty-four hours after the urine has been passed. Becquerel also has observed that urine which throws down no sediment often contains more of the urates than urine which deposits a sediment. Consequently, the cause of the separation of the sediment must be sought elsewhere. Lehmann considers that the cause of the deposition of the urates is to be found in the colouring extractive matter, which also, according to Scherer's observations, occasions the separation of free uric acid as sediment. According to Lehmann, the solubility of the urate of soda is increased by the colouring extractive matter, and the decomposition of the pigment exercises an influence over the entire constitution of this salt.

We have already seen how prone the colouring-matter of the urine is to undergo decomposition, especially when subjected to the influence of the air, and that free acids, in small quantities, are at the same time produced. If, therefore, we expose to the air sediment which is originally colourless, and contains no free uric acid, the beautiful red colour of urine-pigment will first appear in the moist sediment collected on the filter; and if we now endeavour to dissolve it in water, we shall find that more or less uric acid, in the form of beautiful crystals, will remain behind. The phenomenon is readily explained. In consequence of the decomposition of the pigment free acids are formed; these withdraw a portion of its base from the urate of soda, and uric acid is thereby separated, the filtered fluid not having an alkaline but a neutral reaction.

Lehmann considers, from these facts, that he is justified in drawing the following conclusion concerning the origin of uric acid sediments:—Neutral urate of soda is dissolved in the urine, but whenever any free acid is formed through the decomposition of the pigment, the urate of soda undergoes a change; it loses a portion of its base, and the originally neutral salt is separated as an acid urate of soda. This view is strengthened by the fact, that the sediment usually met with consists of acid urate of soda.

Scherer has pointed out in the clearest manner the mode of formation of uric acid sediments; and there is no doubt that his description is correct. He has proved that the decomposition of the pigment-matter is to be considered as the sole cause of their production. Sediment of free uric acid is very rarely found in fresh urine; and we know that the acidity of urine in the first instance invariably increases, that it undergoes, in fact, the acid fermentation, and then deposits crystals of free uric acid. Scherer first observed this process; and Lehmann concludes from it that uric acid sediments are the product of the decomposition which the urine undergoes out of the body. As we have already explained (Sec. I.), the free acid, which is produced through the action of the mucus of the bladder upon the pigment-matter of the urine, readily decompose the lightly-combined salts of uric acid, uniting with a portion of their base, and throwing down the uric acid in a crystalline form. Moreover, it is to be noted, that oxalate of lime may be formed, or at all events separated, during the process of fermentation, for in most cases crystals of oxalate of lime are not found in fresh urine; when, however, the acid fermentation-process has occasioned a precipitate of uric acid crystals, single crystals of oxalate of lime are found mingled with them. Consequently, the formation of oxalic acid appears to be intimately connected with the separation of uric acid.

This fermentation-process of the urine having at length reached its maximum of acidity, a change commences. In the course of a few days, or it may be weeks, the acid disappears, and the surface of the urine becomes covered with threads of fungi, confervæ, and algæ; from the neutral it gradually passes into an alkaline condition, and the crystals of uric acid, which have been separated, disappear, and are replaced by other sediments. The ammonia, resulting from the decomposition of the urea, causes a separation of earthy phosphates, of phosphate of lime as such, and of beautiful crystals of ammonio-phosphate of magnesia. At the same time a portion of the ammonia unites with the uric acid, and forms a sediment of urate of ammonia. The urine in this condition effervesces with acids; the greater part of its pigment is decomposed, and its yellow colour almost wholly lost.

This alkaline fermentation, the promoting agent of which is the decomposed mucus of the bladder, is not in all cases preceded by the acid fermentation. It sometimes occurs at an earlier period, and in fact, within the bladder itself, in affections of its mucous membrane—a proof that urine is sometimes originally alkaline, even when its alkalinity is not caused by the ingestion of organic alkaline salts.

Scherer has also endeavoured to show that this fermentation-process, when it takes place in the bladder, is the chief cause of the formation of urinary calculi.

The ordinary sediments of urine may, in accordance with what has been said, be grouped together in the following way:—

1. *Sediments caused by the acid fermentation.*—The mucus of the bladder acts as a ferment upon the pigment-matter, producing free lactic and acetic acids, whereby are thrown down,—

   1. Free uric acid.
   2. Acid urates (soda, &c.).
   3. Oxalate of lime.

2. *Sediments caused by the alkaline fermentation.*—Carbonate of ammonia is formed in the urine; the free uric acid disappears, and the following salts are separated:—

   1. Ammonio-phosphate of magnesia.
   2. Phosphate of lime.
   3. Urate of ammonia.

Infusoria, fungi, and yeast-globules are formed at the same time.

We will now proceed to the particular consideration of each of these bodies.

I.—UNORGANISED SEDIMENTS.

SECTION XXXVI.

URIC ACID.

Uric acid is not found as a sediment except in very acid urine; it is generally accompanied with urates, especially with acid urate of soda. As a sediment it is always coloured; sometimes it is of a very pale yellow, but ordinarily of a deep yellow, orange-red, or brown colour. Its crystalline condition is readily recognisable even with the naked eye; and when examined with the microscope, it exhibits the various forms already described. (Sect. VI.) Four-sided tables or six-sided prisms of a rhombic character, which by rounding of their obtuse angles form spindle- and barrel-shaped crystals, are characteristic of uric acid. Should, however, any doubt exist as to the nature of the crystals, the sediment should be dissolved on the object-glass in a drop of caustic-potash, and a little hydrochloric acid added to it. By this process we obtain the ordinary forms of the crystals. Uric acid, when mixed with any of the urates, may be separated by heat and filtration; the uric acid salts are thereby dissolved, and the free uric acid left behind on the filter. We may also employ the chemical test, the murexide-reaction, for which an extremely small quantity of uric acid is sufficient. (See Sect. VI., *Plate I. Figs.* 2 and 3, *Plate II. Fig.* 4, *Plate III. Fig.* 1.) Table-shaped crystals of uric acid aggregated together in a fan-like form, as delineated by Funke in his "Atlas" *Plate XII. Fig.* 5, are not so frequently met with in urinary deposits.

SECTION XXXVII.

URATES.

Salts of uric acid, present with free uric acid in the sediment, may be separated, as already mentioned, by warming the urine; they separate again from the filtrate as it cools. All the urates, with the exception of urate of ammonia, are met with only in acid urine. Their colour varies much, especially when they are exposed to the air, whereby they are decomposed. They are usually of a greyish-white, white, rosy-red, brownish-red, or purple-red colour; and in this way often resemble organic substances, such as blood, pus, &c., from which they can only be distinguished by the aid of the microscope. Chemically, their presence is readily shown by their conduct with nitric acid and ammonia (the formation of murexide), as well as by their solubility in hot water.

1. *Acid urate of soda* generally appears in the form of amorphous, irregular granules, of very small size. Prepared artificially, by solution of uric acid in a warm solution of ordinary phosphate of soda, it is obtained as microscopic prismatic crystals, which are usually grouped together in stellate masses. Similar forms are sometimes found in the urine at the termination of its acid and the commencement of its alkaline fermentation. Very complicated forms are often observed under the microscope at this transition-period of the fermentation; the crystals of uric acid, separated during the acid fermentation are now more or less in course of re-solution, and studded

with beautiful groups of prismatic crystals of urate of soda; at the same time concentrically striped balls—probably of urate of ammonia—may be seen here and there scattered over the prismatic crystals. This urine still slightly reddens litmus. As the fermentation proceeds, and when neutral reaction sets in, we also occasionally observe prismatic groups of acid urate of soda; but we now find them accompanied with fine large crystals of ammonio-phosphate of magnesia.

Acid urate of soda is very little soluble in water, requiring 124 parts of boiling, and 1,150 of cold water, for its solution. It is separated from the urine, in a crystalline form, as uric acid, on the addition of hydrochloric acid. Heated with potash, it does not give off ammonia, but leaves a white residue when heated to redness. This residue, when moistened with water, turns red litmus-paper blue, and effervesces with acids (carbonate of soda). Acid urate of soda is usually found in the urine in febrile states of the body, and whenever the respiration, or rather the oxidation of the blood, is impeded.

Plate II. Figs. 1, 2, Urinary sediment of urate of soda. *Plate II. Fig.* 4, Sediment consisting of urate of soda, uric acid, and fermentation-globules, in urine which has been left at rest, and is passing into the stage of acid fermentation. (*Plate I. Fig.* 3).

2. *Acid urate of ammonia* is less frequently met with than acid urate of soda. It is usually found in alkaline urine, mixed with earthy phosphates. Under the microscope it appears to consist of opaque globular masses, from which peculiar delicate spikelets project, like the spines of a hedge-hog. When a drop of hydrochloric acid is added to it, under the microscope, the well-known crystals of uric acid soon make their appearance. It is soluble in boiling water, but separates again as the water cools. Ammonia is generated when it is treated with caustic-potash. With nitric acid and ammonia it yields, like pure uric acid or the other salts of uric acid, the well-known murexide-reaction.—*Plate II. Fig.* 5.

3. *Acid urate of lime* is rarely met with, and only in small quantities. It forms a white, amorphous powder, very soluble in water, which when exposed to a red heat leaves behind carbonate of lime.

Tests.—The recognition of the urates in urinary deposits is by no means difficult. By far the most common of them is the amorphous acid urate of soda. The ammoniacal salt is less frequently met with; it is always readily known by its spiked globular form. When we have satisfied ourselves (by the formation of crystals of uric acid, on the addition of a drop of hydrochloric acid) of the presence of a salt of uric acid in the sediment, we collect the whole of the sediment on a filter. A portion of it is heated on platinum-foil until it is converted into an ash, which is then moistened with water, and tested with turmeric-paper. If the paper becomes brown, the presence of soda or potass is indicated. Another portion of it is heated with caustic-potass; and if ammoniacal vapour, which turns reddened litmus-paper blue, is given off, the presence of an ammoniacal salt is shown. The remainder, however small the quantity of it, may serve for the murexide test. The distinction between urate of soda and urate of ammonia is readily shown microscopically, by treating the washed sediment with hydrochloric acid, and allowing it to evaporate slowly on the object-glass. The microscope shows (in addition to the crystals of uric acid which are separated) cubes of chloride of sodium if urate of soda was present, or the efflorescence of sal ammoniac if urate of ammonia existed in the urine.

SECTION XXXVIII.

Oxalate of Lime.

Composition of hydrated oxalic acid:—

In 100 parts:	Carbon . . .	26·667
	Oxygen . . .	53.333
	Water	20·000
		100·000

Formula: $C_2O_3 + HO$.

A. *Origin.*—Although oxalic acid is widely distributed through the vegetable kingdom, it is only met with in very small quantities in animal bodies, and always in combination with lime. Oxalate of lime appears in the urine, both normally and pathologically, as a sediment in the form of well-marked crystals. It is chiefly met with in cases of impeded respiration, in emphysema of the lungs, and during convalescence from severe diseases, particularly from typhus. According to Lehmann, the oxalate of lime is held in solution in the urine as it comes fresh from the bladder; and this seems probable, inasmuch as the oxalate is tolerably soluble in a solution of biphosphate of soda, which is the chief source of the free acid in healthy urine. We may, indeed, according to Lehmann's assertions, readily satisfy ourselves of this. The urine is filtered and evaporated, and moderately concentrated spirits of wine added to its solid residue;

ether is next shaken with the spirituous extract, and after this operation we find in the alcoholic extract a sediment, which is insoluble in water, and consists of beautiful crsytals of oxalate of lime.

Oxalate of lime separates from filtered urine only after it has stood for some time, together with a few uric acid crystals. Oxalate of lime, again, is often separated in large quantities, as soon as the acid fermentation of the urine commences, and is then readily found in the sediment with uric acid. (Sect. xxxv.)

Vegetable diet, effervescing wines and beer, as well as the internal use of bicarbonates of the alkalies, alkaline salts of organic acids, free uric acid and salts of uric acid often increase the quantity of oxalate of lime in the urine.

Beneke has made some very interesting observations respecting the origin of oxalate of lime in abnormal urine. (Beneke, *der phosphors. und oxals. Kalk.* Göttingen, 1850.)

B. *Microscopical Characters.*—Oxalate of lime, prepared artificially (as by the precipitation of a salt of lime with oxalate of ammonia, &c.), appears, under the microscope in the form of perfectly amorphous masses, in which not the slightest trace of crystallisation is observable. Separated, however, from the urine in the form of a sediment, it assumes very characteristic forms. Crystals of the oxalate of lime thus obtained appear in the form of small, shining, well-defined, perfectly transparent, square octohedra, having a strongly refractive power. Some of the crystals, however, are occasionally found with very acute angles. Beneke, in the work above referred to, also describes peculiar hourglass-shaped crystals, and others, of a square columnar form, with pyramidal summits. (Beneke, *Plate I. Figs.* 4 *to* 10.) (Funke, *Plate I. Fig.* 1. *Plate I. Fig.* 3.)

Beautiful crystals of oxalate of lime separate from urine which throws down no sediment, when a dilute solution of oxalate of ammonia is carefully poured over without disturbing it. I have in this way artificially prepared a large quantity of most beautiful crystalline forms. The relation of oxalate of lime to acid phosphate of soda is interesting. When common phosphoric acid is added to a solution of ordinary phosphate of soda, until a drop of the mixture, on testing, is found to be no longer clouded by a solution of chloride of barium (a proof that the fluid contains only acid phosphate of soda), dilute solutions of chloride of calcium and oxalate of ammonia may be added in drops, without occasioning any turbidity or separation of oxalate of lime. If very dilute caustic-soda is now carefully dropped into this solution, which remains clear even after

[illegible]

[illegible]

[illegible]

[illegible] the supernatant [illegible] is poured off and [illegible] is then [illegible] under the microscope.

phosphate of magnesia, both of which compounds are in most cases met with together. It rarely happens that one of them exists alone in the urine. They do not form in acid urine, on account of their ready solubility, even in very weak acids. They never appear except when the urine has undergone the alkaline fermentation, either within or out of the bladder.

1. *Ammonio-phosphate of Magnesia.*—This sediment is not met with in healthy urine; but it always appears in the form of remarkably beautiful crystals, when the urine becomes alkaline. In some diseases—in serious affections of the bladder or spinal marrow—large quantities of sediment is often found, consisting of these crystals. In diabetic urine, Lehmann once observed a white shining sediment, which consisted solely of ammonio-phosphate of magnesia, without a trace of lime.

The crystals of this double compound (the triple phosphate) may be always readily recognised by their characteristic forms. The forms most frequently met with are combinations of right rhombic prisms, *Plate II. Fig.* 3, *Fig.* 5. The crystals are insoluble in hot water, but readily dissolve on the addition of acetic acid, and may be thus distinguished from those forms of oxalate of lime to which they bear a resemblance. They are not affected by alkalies.

2. *Phosphate of Lime,* as a sediment, forms an amorphous, and frequently also a crystalline powder. It is insoluble in water; but soluble in acids, even in acetic acid, and is precipitated from their solutions by alkalies in an amorphous state. Consequently, this sediment only appears in slightly acid, neutral, or alkaline urine.

Phosphate of lime, in urine which has only a feebly acid reaction, is frequently held in solution by carbonic acid only, and is separated in white flakes, closely resembling those of albuminous coagula, when the carbonic acid is expelled by boiling.

Sediments of crystalline phosphate of lime are also not unfrequently met with, and sometimes mingled with triple phosphates. The size, form, and grouping of the crystals of this phosphate of lime vary considerably, but they always present signs sufficiently characteristic to admit of their being at once recognised under the microscope. The crystals are sometimes solitary, and sometimes aggregated, frequently forming coils and rosettes. At times they are thin and acicular, often forming globe-like glands of crystals, by lying upon and crossing each other at right angles. Again, they are often small and smooth, and present sharp or pointed extremities.

[illegible] -shaped, [illegible] parts of [illegible] somewhat [illegible] surfaces.

[illegible] crystalline [illegible] quantity, and of [illegible] by the [illegible] Jones, [illegible] of lime- [illegible] phosphate [illegible] phosphate

[illegible] particularly of [illegible] the [illegible] their [illegible] Should [illegible] tests [illegible] in hot [illegible] of lime, [illegible] with [illegible] acid, [illegible] occur [illegible] recog- [illegible] solubility in liquids. [illegible] any doubt upon [illegible]

Composition.— [illegible]

A. *Origin.*—Cystine was originally discovered in a urinary cal-
lus, but it has since been often found in the urine in a state of
lution, and precipitated out of it by acetic acid. It is also found
a sediment mixed with urate of soda. The occurrence of cystine
a urinary calculus is very rare; of 129 specimens of calculi only
o contained cystine. (Taylor.) Cloetta has recently found cystine
the juice of the kidneys, together with inosite and hypoxanthine.
herer on one occasion found it in the liver.

Julius Müller (Archiv d. Pharmac., March, 1852, p. 228),
scribes a urinary calculus containing cystine, which was removed
operation from the bladder of a boy 6½ years of age. The
ine of this boy, which could only be obtained in small quantities
fore the operation, threw down an alkaline sediment, containing
umerous mucus corpuscles, but neither uric acid nor earthy
hosphates. Only a small quantity of urate of soda, but much
loride of sodium was found dissolved in it. The calculus weighed
68¾ grains, and contained 55·55 per cent. of cystine. Imme-
iately after the operation the urine presented an acid reaction, threw
own a mucous sediment, and contained less uric acid and earthy
hosphates, than healthy urine. Eight weeks later the alkaline
action again appeared in it; it contained much chloride of sodium
nd urea, but only a trace of uric acid. On standing, it deposited
sediment of ammonio-phosphate of magnesia and cystine, which
as readily recognised by its crystalline form under the microscope,
fter the removal of the magnesian-salt by acetic acid. The filtered
rine also, when acetic acid was added to it, threw down a precipi-
ate in the course of twenty-four hours, which when dissolved in
mmonia, left on evaporation of the solution, the characteristic micro-
copic tables of cystine. From this it follows, that the production
f the cystine in the urine of this lad continued after the operation.

Toel (*Annual. d. Chem. et Pharm.* vol. 96, p. 24) has made
ome interesting observations at Bremen concerning the production
f this remarkable substance, in the case of two young women, by
hom it was constantly passed with the urine, partly in solution
nd partly as a sediment. These women had suffered from calculus
f the kidney. The quantity of the cystine separated reached in each
n average of about 1.4 gramme in 24 hours.

B. *Microscopic characters.*—Cystine crystallises under the micro-
cope in the form of transparent, colourless, six-sided plates or
risms. As, however, uric acid occasionally crystallises in six-sided
ables, the microscopic investigation of the cystine-crystals does not

ffice for the determination of their nature. The sediment must, erefore, be examined chemically. (*Plate III. Fig.* 4.)

c. *Chemical characters.*—Cystine is a neutral body, without taste d smell, insoluble in water, but soluble in mineral acids and in alic acid, with which it forms saline compounds, that readily ndergo decomposition. It is not soluble in acetic or tartaric acids.

2. Cystine treated with nitric acid is decomposed and dissolved, nd on evaporation of the fluid a reddish-brown mass is left, which oes not give the murexide-reaction with ammonia.

3. Heated on platinum-foil, cystine does not fuse, but burns with a luish-green flame, giving off a sharp, acid, and characteristic odour, hich resembles that of prussic acid. Subjected to dry distillation, t yields ammonia and a fetid oil, a porous coal remaining as residue.

4. Caustic alkalies and carbonates of the fixed alkalies, as well as austic ammonia, readily dissolve cystine, but carbonate of ammonia loes not. Consequently, we always precipitate it from its acid olutions by carbonate of ammonia, and from its alkaline solutions y acetic acid.

5. Cystine boiled with caustic-potash, in which oxide of lead has been previously dissolved, throws down a large quantity of sulphuret of lead. (Liebig.)

6. When cystine is boiled with caustic-potash, ammonia is produced, and a gas which burns with a blue flame.

D. *Tests.*—Cystine is chiefly characterised by its crystalline form, by its solubility in mineral acids and alkalies, and by its conduct when exposed to heat or mixed with nitric acid. Liebig has also proposed as a test its reaction with caustic alkali and oxide of lead, which when boiled with cystine yield a large quantity of sulphuret of lead. But in the application of this test, it must be remembered, that other bodies which contain sulphur, such as albumen, fibrine, &c., act in a similar way: it is therefore always necessary to ascertain that none of these bodies are present, or if any should be present, to remove them before commencing operations.

Cystine may be readily distinguished from any of the earthy phosphates or urates which may be mixed with it, by boiling the urine and treating it with acetic acid. The boiling and acetic acid do not affect the cystine, but dissolve the others. Uric acid, which, as we have already stated, occasionally crystallises like cystine in six-sided tables, is easily distinguished from it by the murexide-test. Cystine, when subjected to the same test, leaves a reddish-brown mass.

SECTION XLI.

TYROSINE.

(*Compare with Section* 34.)

Städeler and Frerichs found a greenish-yellow crystalline sediment in the urine of a woman, who was suffering from acute atrophy of the liver, after it had been allowed to stand for a short time. This sediment was considerably increased when the urine was slightly evaporated. It was extracted by the action of dilute ammonia, and the crystals first separated from the solution were then recognised as tyrosine. Another more soluble compound, probably homologous with tyrosine, remained in the mother-liquor; it contained 8·83 per cent. of nitrogen. The tyrosine contains 7·73 per cent. of nitrogen.

II. ORGANIC SEDIMENTS.

SECTION XLII.

MUCUS AND EPITHELIUM.

Animal mucus is the product of the secretion of the mucous membranes, and holds in suspension the different forms of the epithelial cells, which have been separated from their surface. Urine always contains mucus, secreted from the mucous membrane of the bladder. When the urine is left at rest the mucus separates in the form of cloudy, transparent flocculi; and if, after the mucus has thus gathered together, the urine be filtered, most of the mucus remains on the filter in separate, transparent, colourless masses; it then shrivels up and forms a shining, varnish-like layer.

Mucine is the essential constituent of mucus, and the offshoot of a proteine-body; it imparts to the fluid in which it is dissolved, even though its quantity be small, a tough, thready consistence. A solution of mucine is not coagulated by boiling (and in this it differs from albumen); but it readily coagulates on the addition of alcohol, which throws down the mucine in dense flocculi. Acetic acid, as well as a solution of alum precipitate mucine; the thread-like masses thrown down by acetic acid somewhat form of narrow or broad twisted bands, arranged in rows, and consisting of extremely fine points and granules; it is very frequently associated with the sediments of acid urate of soda.

These mucous coagula (*Plate II. Fig.* 2) occasionally resemble somewhat the casts of granular kidney (*Plate I. Fig.* 6), and may therefore be a source of error. A little practice, however, readily enables the observer to distinguish the one from the other.

SECTION XLIII.

BLOOD.

The presence of blood in the urine is not a rare phenomenon, and may be demonstrated without any great difficulty. The existence of blood-corpuscles in the urine, as shown by their microscopic characters, is an important test, being demonstrative of the presence of blood.

A. *Microscopic characters.*—Normal blood-corpuscles are small round cells, probably filled with fluid matters—hæmato-crystalline. They cannot be confounded with any other object when examined under the microscope. They appear as thick, circular, and slightly-biconcave discs, with rounded borders, a colourless membrane, and contain a reddish, or by transmitted light, yellowish, tenacious fluid. These blood-corpuscles have no distinct nucleus, and only a few of them exhibit in their concave centre an ill-defined nucleolus. They are for the most part massed together in a nummular form. Their size in man equals about 0·00752 MM. (*Plate I. Fig.* 6. *Plate III. Figs.* 1 *&* 2). They undergo peculiar changes and modifications of form under the influence of alkaline salts and of other bodies. These changes require consideration.

1. *The action of water on blood-corpuscles.*

The alterations which blood-corpuscles undergo in water vary according to the quantity of water employed, and the length of time they have been mixed with it. (These changes are shown in *Plate*

III. Fig. 2. proceeding from left to right.) Under the action of water the cells swell out, assume at first a somewhat lenticular form, and finally that of a sphere; their central depression is elevated, and gradually bulges out, which necessarily occasions a diminution of the diameter of each disc. The corpuscles now appear smaller, the central shadow gradually vanishes, whilst a circular shadow comes into view at their border. The cells, if still further subjected to the influence of water, become fainter and paler, presenting the appearance of thin hyaline vesicles, which gradually become invisible.

2. *Blood-corpuscles treated with saline solutions, &c.*

Blood-corpuscles treated with a concentrated solution of a neutral salt, such as sulphate of soda, become much contracted. This change is chiefly recognised, under the microscope, by the more marked character of the central depression thence resulting; the shadow which indicates it approaching nearer the border of the disc than it does in the healthy blood-corpuscles. The borders of the blood-corpuscles at the same time lose their circular form; they become more or less distorted, oblong, or angular, and, instead of being smooth, are notched and jagged. If blood-corpuscles which have been rendered invisible by the action of water are treated with a concentrated solution of sulphate of soda, they again become visible, but appear in the form just described, distorted, angular, and jagged. (Funke, *Plate IX. Fig.* 3.) *Plate III. Fig.* 2, below to the right.

Caustic alkalies and many of the organic acids, such as acetic acid, distend the corpuscle, altering its shape, and destroying it more or less rapidly.

The organic colouring-matter, which forms the chief contents of the red corpuscles, can be made to assume a crystalline form when the blood is subjected to certain simple external influences. Funke has given it the name of hæmato-crystalline. (Funke, *Plate X. Figs.* 1-6.)

B. *Tests.*—In most cases the blood-corpuscles found in urine which contains blood do not present their normal form. If the urine be acid, they may retain their shape for a tolerably long time, being only a little jagged at their borders; usually, however, they are distended and of a spherical form. Their colour is lighter than natural; they still present a well-defined contour, but they no longer adhere together in nummular masses. These changes are of the me kind as those described above, and are to be attributed to the tion of the watery and saline constituents of the urine. *Plate I. ig.* 6. *Plate III. Fig.* 1.

When the quantity of blood is small the urine containing it is left rest for some time in a conical-shaped test-glass. The blood-obules are deposited at the bottom of the glass (in the apex of the ne), and the presence of the blood may be generally at once cognised with the naked eye. The clear-filtered urine, if blood be esent in it, will also be found to contain albumen. (Sect. XIX. *Tests for Albumen.*)

If the microscope fails to discover blood-corpuscles or their rudi-ents, chemistry must be appealed to, but it, unfortunately, cannot ive us much assistance. If the blood-corpuscles are destroyed or issolved, they usually give the urine a reddish-brown colour; and e urine is rendered albuminous by the presence of the blood. On arefully adding acetic acid to such urine and heating it, we obtain reddish-brown coagulum, which becomes almost black when dried. his coagulum, when dried and powdered, and treated with alcohol ontaining sulphuric acid, imparts to the fluid a reddish or reddish-rown colour, if hæmatine be present in it; and the mixture evapo-ated and heated to redness leaves an ash which contains iron. lthough iron may exist in healthy urine, its presence in the dilute lcoholic solution, above mentioned, must always be considered as dicative of blood in the urine, especially if there are other co-xisting signs of the presence of blood in that fluid. Iron, however, btained directly from the ash of urine must never be considered as proof of the presence of blood in the urine.

Heller, in testing for hæmatine, boils the urine, and then adds to it con-entrated caustic-potash. Any albumen which may have been precipitated s dissolved, and if hæmatime is present, the fluid becomes of a bottle-reen. On further boiling, and shaking the mixture, the earthy phosphates re precipitated, carrying down with them the hæmatine, and sometimes ssume a brownish-red, or a blood-red, and often by dichroism yield a reen colour to transmitted rays of light.

According to Heller, the reaction is more certain when the colouring-atter of the blood is partially decomposed and has lost its red colour (?). f the phosphatic coagulum happens to be coloured by rhubarb, senna, antonine, &c., and not by hæmatine, we shall find that it becomes violet fter it has stood some time in the air, and that it is not rendered dichroistic y potash like the precipitated hæmatine-coagulum.

SECTION XLIV.

PUS.

The only sure proof of the presence of pus in the urine is obtained through the microscope. Chemistry assists us here even less than in the case of blood in the urine.

A. *Microscopic characters.*—Normal pus-corpuscles appear under the microscope as round, pale, indistinctly granular vesicles of various sizes. A distinct nucleus is usually visible in them; it is, in most cases, simple, and in others split up and imperfect. All the corpuscles do not possess a well-marked contour; in some of them the outline is indistinct, as if it had been washed out.

1. *Pus-corpuscles acted on by water.*—When fresh pus is mixed with a good deal of distilled water, the corpuscles soon become pale and swollen, and their borders thin; their granular surface generally disappears, the nuclei come prominently into view, and a few small, dark, point-like granules become visible. These changes may be very readily and satisfactorily studied by observation of the corpuscles of the mucous membrane of the mouth; the simple, and in most cases lenticular nucleus of these corpuscles is very distinctly seen when water is added to them. (Funke, *Plate IX. Fig.* 4.)

2. *Pus-corpuscles acted on by acetic acid.*—Under the action of dilute acetic acid or of any other organic acid, or very dilute mineral acids, the pus-corpuscles swell up, sometimes becoming twice as large as natural; their surface loses its granular aspect, their walls become extremely hyaline and often burst; the jagged and torn remains of them being here and there visible in the field of the microscope, with the aid of a good light. The nuclei previously observed now come prominently into notice, varying both in form and in number; in part they appear round, oval, lenticular, or horse-shoe shape; and in part, again, made up of two, three, or more parts in different groups, as if from the splitting up of the simple nucleus. (Funke, *Plate II. Fig.* 3, *Plate VIII. Fig.* 6.) *Plate III. Fig.* 3, upper half.

3. *Caustic alkalis* rapidly destroy pus-corpuscles; they do not, however, wholly dissolve them. The corpuscles often remain visible for a short time, but disappear on the addition of water, leaving a

latinous kind of residue, in which a few single points may be more less readily recognised.

B. *Tests.*—We must trust almost wholly to the microscope in arching for pus in the urine; chemistry gives us very little assist-ce in distinguishing its characters. The appearance of pus under e microscope has been described above. The corpuscles of pus e distinguished from blood-corpuscles chiefly by their behaviour hen treated with acetic acid, and also by their granular surface. *Plate I. Fig.* 6. *Plate II. Fig.* 3.)

Pus soon sinks to the bottom in acid urine, which is left at rest, and hen the supernatant urine is removed by a pipette, may be collected d subjected to microscopical examination. Blood-corpuscles are t unfrequently mixed with purulent sediments, and may be recog-sed by their red colour, or still more surely by the microscope. In ther case the clear, filtered urine will contain albumen (Sect. XIX., C.). alkaline urine pus undergoes essential changes, which are of par-cular interest, by reason of the fact, that alkaline urine is often acuated containing a considerable quantity of pus, in cases of tarrh of the bladder, &c.

Alkalies convert pus into a muco-gelatinous mass, which adheres the side of the vessel, exhibits no pus-corpuscles under the micro-ope, and may be readily taken for mucus. In most cases, how-er, in addition to this tough mass, pus-cells may be found suspended the urine, if it be examined soon after it is passed.

Pus may be readily distinguished from mucus by this behaviour nder the action of alkalies. The sediment in question is treated ith concentrated caustic-potash; if it consist of pus, the gelatinous ass above described is formed, and if of mucus, a thin flocculent fluid. Donné's Test for Pus.)

As the serum of pus contains albumen, albumen is always present urine, which contains pus; consequently, we can always form an pproximate estimate of the quantity of pus from the amount of lbumen in the filtered urine—provided, of course, there is no co-xisting albuminuria. The presence of blood in the urine must lso be taken into consideration, as a source of part of the albumen und in the urine.

SECTION XLV.

URINARY CASTS OR CYLINDERS.

In many diseases, and especially in Bright's disease of the kidneys, peculiar tubular or cylindrical bodies are found in the sediment of the urine. These bodies have long been the subject of investigation. They differ somewhat in their structure, and have consequently been divided by Lehmann into three different kinds:—

1. Cylinders, which appear to be formed of the epithelial covering of the tubules of the kidney; these are found in almost all cases of inflammatory irritation of the kidneys, and form regular cylinders around which small cells and cell-nuclei appear grouped, somewhat in the form of a honeycomb. (*Plate I. Fig.* 4.)

2. Cylinders which appear to have been formed from exudation effused into the tubules of the kidney, whose form they retain. These cylinders consist of small granular rods, which are frequently garnished with blood- and pus-corpuscles. They seem to consist of fibrine, for they readily dissolve in alkalies,—the blood- and pus-corpuscles, which they enclose being also thereby partly destroyed, and partly left in suspension in the fluid. They are always present in Bright's disease. (Frerichs, *Die Bright'sche Krankheit. Plate I. Fig.* 6.)

3. Lastly, we sometimes meet with cylinders which are hollow, and possess hyaline walls of so fine a structure that it is with difficulty they can be distinguished from the surrounding fluid. These often appear collapsed, and in folds, or as if twisted around their own axis. In the chronic form of Bright's disease they only appear singly. (Lehmann.) *Plate I. Fig.* 5.

Tests.—To demonstrate the presence of these bodies, the urine, which is in most cases highly charged with albumen, is allowed to stand for some hours in a conical glass. The sediment which forms is generally white and flaky, or if other substances are present, may consist of a thickish mass. In this sediment, examined with a 180 to 200 magnifying power, the presence of the casts, &c., is readily ascertained. Sometimes, indeed, the hyaline cylinders (described at 3) may escape observation, but they are at once rendered visible by the addition of a solution of iodine in iodide of potassium, which gives them a yellow colour. When, as often happens, only a few cylinders are present, different specimens must be prepared and carefully examined. Fat, pus, epithelium, blood, &c., frequently co-exist with the cylinders in these sediments.

Care should be taken not to mistake the coagulated mucus in acid urine (described in Section XLII.), which is often found mixed up with urate of soda, for granular urinary casts. (*Plate II. Fig.* 2.) See Mucus, Sect. XLII.

Cancer and tubercle are described elsewhere.

SECTION XLVI.

SPERMATOZOA.

Spermatozoa appear under the microscope as elements of a spherical, or of nearly a spherical form, having a well-defined tail, which is generally pointed, varies in length, and is capable of spontaneous motion. We find them in the urine after coitus, &c.; and they have also been frequently noticed in the urine of patients suffering from typhus.

The form of these spermatozoa is so characteristic, that they cannot possibly be confounded with any other microscopic objects. They are also very indestructible, a fact which much assists us in the diagnosis of semen in the urine. The urine is allowed to stand at rest for some hours in a conical-shaped glass, so that the spermatozoa may be separated, and sink to the bottom with the flocculi of mucus. The greater part of the supernatant fluid is then carefully poured off, and a drop of the sediment from the very bottom of the glass placed under the microscope. If the little thready bodies of spermatozoa are present, they are at once recognised by their tadpole-like form, above described. A magnifying power of 300 to 400 diameters is requisite for the purpose. In pure water, as well as in urine, especially if it be very acid or alkaline, they soon lose their movements; they also often undergo a peculiar change of form, the hinder part of the tail being curved round towards the fore part, and spirally rolled up. The observation of Lehmann is worthy of note, viz., that urine which contains semen very readily becomes alkaline, and that in its mucous sediment, peculiar, fine, lamellar-like, and very transparent, spots are to be found, although very few spermatozoa are visible.

Clemens has frequently noticed the passing away with the urine of imperfectly-formed semen; the spermatozoa lying in the cells and adhering by their head and tail to the envelope; the tails seldom showed any signs of motion, which only takes place in perfectly-formed semen. Besides these spermatic cells, Clemens often observed in the urine of patients suffering from spermatorrhœa, roundish cells of 0·0033 to 0·005‴ diameter, filled with fine granules, which lay for the most part on one side of the cell. These cells are in reality the mother-cells of the spermatozoa. Such elementary bodies are generally found in the last drop of urine of patients who have been much depressed by loss of semen, and also in typhus-fever patients. (Canstatt's Jahresbericht, 1860, p. 285.)

SECTION XLVII.

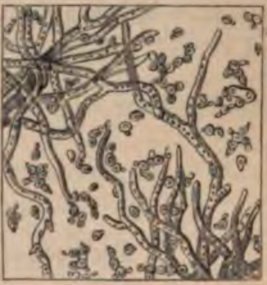
FUNGI.—INFUSORIA.

Fungi and Infusoria are always found, microscopically, in urine which has stood for some time. They are also sometimes present in urine which has undergone decomposition within the bladder, as for instance, in cases of catarrh of its mucous membrane.

The infusoria are generally very small, and most frequently appear as point-like monads, or as a string of pearls or branched vibrios. At the commencement of the decomposition of the urine only few vibrios are observed, but as the process advances they become more numerous, collect on the surface, and mixed with triple-phosphates and fungiform a pellicle, which breaks up, and finally sinks to the bottom. Dr. Hassal noticed a second kind of infusoria in the urine, the *Bodo urinarius*; those which were alive and in motion were oval and round, $\frac{1}{1600}'$ long, and $\frac{1}{1300}'$ broad, granular and like mucus-corpuscles. They were often broader at one end, and furnished at different points with one or more, generally two or three, threads or ciliæ. They multiplied by division. Dr. Hassal considered them to bear a close resemblance to the *Bodo intestinalis* of Ehrenberg. They most commonly are met with in albuminous urine associated with vibrios. The species of fungus most frequently met with is the urine-fermentation fungus, having the form of roundish, or oval nucleated cells, which are formed out of the decomposed mucus. These cells exist singly, or are associated together in rows and groups. (*Plate II. Figs.* 2 and 4.) They are frequently, in advanced stages of the urine-fermentation, mixed with the sediments of urate of soda, free uric acid and oxalate of lime.

The fungoid cellules, formed during the fermentation of diabetic urine, are oval, transparent, and considerably larger than those above described, and in their form and mode of development correspond with the ordinary yeast-plant. Their usual form is oblong, occasionally it is round, their size is variable; all of them have a distinct round nucleus, which often looks like a hole. Together with them, threads of confervæ are formed, containing sporules which are forked and branched; and when the urine has stood for some time, they often form a dense confused mass, which occupies the whole field of the object-glass. Dr. Hassal has found, besides these, other fungus-forms in alkaline urine which contains albumen.

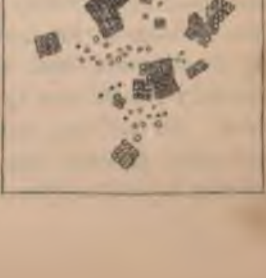
FIG. 2.



Sarcinæ have lately been found by Dr. P. Munk in the urine of a man 43 years old. The freshly-passed urine had constantly an alkaline reaction, was thick, and slightly albuminous. Numerous white transparent bundles of sarcinæ, somewhat rounded at the corners, were seen under the microscope, together with epithelia, a few blood-corpuscles, pus-cells, vibrios, and triple-phosphates. The urine deposited, on standing, an abundant whitish sediment consisting chiefly of sarcinæ and the other substances above named. During May and June this sediment formed from $\frac{1}{13}$ to $\frac{1}{20}$ part in the whole of the urine passed during 24 hours, and collected in a glass. In autumn the sarcinæ decreased considerably, and almost vanished in October.

Dr. Munk found in the urine single sarcinæ, and also bundles containing 8, 64, and 512 sarcinæ. (Fig. 3.) He also observed masses which resulted from

FIG. 3.



the breaking-up of the large bundles. Single sarcinæ were in size from 0·0008 to 0·0016 MM.; the bundles of 8 sarcinæ had a breadth of 0·0016 to 0·0034 MM.; those of 64 a breadth of 0·0032 to 0·006 MM.; those of 512 a breadth of 0·008 to 0·012 MM. The sarcinæ of the urine are therefore much smaller than the sarcinæ found in the stomach. The peculiar form of sarcinæ, as described by Virchow, was distinctly recognised in the bundles and especially when the objects were rolled over under the microscope. Neither tables nor plates were seen. The reaction of the urine appeared to have no influence over the development of the sarcinæ; in this case it was always alkaline; in the case observed by Welka it was sometimes acid, and occasionally neutral. (*Archiv f. Path. Anatom. u. Physiol.*, Vol. xxii., p. 570.)

SECTION XLVIII.

Occasional Constituents of the Urine.

Under this head are to be considered the changes which substances undergo in their passage from the blood into the urine. The importance of the study of these changes is evident enough. It opens to us an insight into the manifold metamorphoses, to which the materials that form the body are subjected, and into the mechanism of the animal body. A very extensive series of investigations, followed out into their smallest particulars, would, however, be necessary to enable us to arrive, in this way, at any useful and general conclusions. The most satisfactory way of proceeding is, therefore, to observe the results which follow when organic substances—whose chemical composition is thoroughly known, and whose products of decomposition have been closely investigated—are introduced into the body; from a consideration of the changes which these undergo in the body, we may arrive at conclusions concerning the chemical forces which are in action there, and which more especially preside over the organic metamorphoses going on in the blood. Of oxidising agents permanganate of potash is the most serviceable in such investigations, for its action on the bodies in question is particularly well marked, and, moreover, the oxidation goes on in the blood just as it does in an alkaline solution. Thus by the action of permanganate of potash the same products have been obtained from uric acid as are generated in the body when the respiration is normal or more or less disturbed: viz., carbonic acid and urea, or carbonic acid, oxalic acid and urea, or, lastly, allantoine, carbonic acid, oxalic acid, and urea.*

A further illustration of the fact is given by guanine. Guanine introduced into the body is in great part converted into carbonic acid and urea; and the same bodies (together with oxalic acid and oxyguanine (?) may be obtained from guanine by the action of permanganate of potash.

Wöhler, assisted by Frerichs, was the first person who worked out this subject, and the results of his investigations are given at length in the *Annal. d. Chem. u. Pharm.*, Vol. lxv., p. 335. *Zeitschrift für Physiologie*, Vol. lxv., p. 305.

The following facts must be premised, before we proceed to the consideration of these accidental substances.

It is evident, as a rule, that only those substances can pass unchanged into the urine which, in the first place, do not serve for nutrition, and which, secondly, are soluble in water, and have no tendency to form insoluble compounds with the organic or inorganic materials of the body. Consequently, the most soluble of the alkaline salts will readily pass into and be found unchanged in the urine. If again we take into the body a substance which is not oxidised, but which has a tendency to undergo oxidation, we shall find it again in the urine in an oxidised state. Sulphide of sodium, which always passes into the urine in the state of sulphate of soda, is an example of this. All substances, however, which form, with the organic matters of the body, compounds that are insoluble, or difficult of solution, such, for example, as most of the metals form with proteine-bodies, only reappear in the urine when they have been taken in large quantities—a fact pointed out by Orfila.

Moreover we find that many organic substances undergo the same changes in their passage through the body, as they may be artificially made to undergo out of the body. Others, again, become so completely oxidised, that it is not possible to find either them or the products of their decomposition in the urine. There are, on the other hand, some substances which give off oxygen and appear in the urine in a lower stage of oxidation.

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* Städeler, as we have already mentioned, found allantoine in the urine in cases where the respiration was impeded.

Lastly, we have to consider the length of time required by any substance to pass into the urine. We find as a rule, that substances easy of solution are quickly separated from the body with the urine. There appears, however, to be some difference in individuals in this respect. Thus, Lehmann, for instance, has observed, that not a trace of iodine could be found in the urine of several individuals, twenty-four hours after they had taken a dose of 10 grains of iodide of potassium, whilst in others it was still present after an interval of three days.

We have now to consider the conduct of different substances in the body :—

1. *Inorganic Compounds.*

A. *Salts of the heavy metals.*—The salts of the heavy metals form, with many animal substances, and particularly with proteine-bodies, compounds difficult of solution, consequently they only appear in the urine when large quantities of them have been introduced into the system. In this way, Orfila found antimony, arsenic, zinc, gold, silver, tin, lead, and bismuth in the urine after large doses of the metallic salts had been taken; but they could only be found in the liver and its secretions, as well as in the solid excrement, when taken in relatively small and oft-repeated doses. Iron, when taken internally may be often immediately discovered in fresh urine by the ordinary tests; but in other cases again it can only be found in small quantities in the ash of the residue of urine (Lehmann).

To ascertain the presence of the heavy metals in urine, the process must be followed, which is employed in judicial cases, where salts are found mixed with organic matters. On this head, therefore, I shall refer the reader to Fresenius' *Introduction to Qualitative Analysis*, 11th edition.

Mercury.—Electrolysis has of late been frequently employed for determining the presence of mercury in the urine; and on account of the importance of the subject, the process employed by Schneider is here described. Five grammes of chlorate of potash are dissolved in each litre of the urine to be tested, hydrochloric acid is added to impart a strong acid reaction, and the mixture then heated in a water-bath. If a dark coloration should appear during the evaporation, a further quantity of the oxidising agent is added, and the heat continued, until, on testing a portion, it is found that on the addition of hydrochloric acid, no bleaching action is exercised on the colouring-matters. There is, however, no advantage in continuing the evaporation of the urine until the salts crystallise, for the fluid becomes of a dark colour when concentrated up to this point. Schneider satisfied himself, by repeated experiments, that highly concentrated solutions do not serve well for the purpose of electrical analysis. In most cases a large quantity of urine is required.

Schneider collected the whole of the urine passed during from three to six days—7 to 15 litres—and after the addition of potash and hydrochloric acid, concentrated it to $\frac{1}{7}$ or $\frac{1}{8}$. For the electrolysis of the urine thus prepared he made use of a Smee's battery of six elements—a constant battery is equally serviceable—whose anode consists of a platinum plate four centimetres broad, and whose cathode of gold wire one millimetre thick runs into a club-shaped thickened extremity two millimetres in diameter. In order to limit the separation of the mercury to the smallest possible surface, the electrolysis is conducted in a vessel of greater breadth than height. The action is kept up for eighteen to twenty-four hours. For the further proof that mercury is present on the gold wire, at the conclusion of the experiment, the following proceeding is resorted to. The gold wire is introduced into a carefully cleaned glass tube, drawn out at one end into a fine capillary point, and then melted and closed at the other. The wide end of the tube, containing the metal, is then heated to redness; and if in the course of about five minutes a deposit takes place on the colder part of the tube, the deposit is then driven by heat towards the capillary end of the tube; and the metal again heated to see if a new sublimate appears. The portion of the tube containing the metal is now separated by fusion from the capillary portion so as to leave a short piece of the wider tube connected with the capillary portion and forming a kind of bulbular expansion. When cool the bulb is opened by nipping off the drawn-out pointed extremity, so that a little iodine may be introduced into it by means of a glass thread, and is then again closed up. The iodine-vapour rises up into the capillary portion of the tube, and disappears at the part where the mercury exists; and then according to the quantity of iodine employed, brown, red, or yellow rings appear. If the brown rings are carefully heated, iodine is driven off, and red rings of iodide of mercury remain. The red as well as the yellow rings volatilise when more strongly heated, but are immediately re-deposited of a red colour, on a cooler part of the tube;

sometimes, however, they take a yellow hue. The yellow rings consist of prot- and sub-iodide of mercury; they arise when the quantity of the iodine introduced is insufficient to form prot-iodide. On the introduction of another crystal of iodine into the capillary tube and heating, the yellow rings are readily converted into red. The red crystals appear under the microscope as rhombic octahedra, with their faces often superimposed, so as to resemble the feathery forms of sal-ammoniac.

No mercury was discovered by electrolysis in three trials, in which the urine contained much iodide of potassium, the urine having been concentrated to $\frac{1}{10}$ after the addition of chlorate of potash and hydrochloric acid. When, however, the urine was treated with sulphuric acid containing nitrous acid, and evaporated in a water-bath until the whole of the iodine was driven off, the cathode showed distinct traces of mercurial silvering, and subsequent testing by heat gave the manifest reaction of mercury. Consequently it is advisable that the urine to be tested should be first of all freed from any iodine which it may contain. This may be readily accomplished by heating it in a warm bath after the gradual addition of sulphuric acid containing sulphurous acid.

Kletzinsky evaporates the urine (previously treated with chlorate of potash and hydrochloric acid) to dryness, and then operates upon the residue with ether to separate the sublimate. This process, according to Schneider, is not to be trusted, for the residue contains the sublimate in union with the alkaline chlorides in the form of a double salt. These double compounds are almost insoluble in ether, and consequently sublimate cannot be dissolved by ether out of the residue of evaporated urine, when completely dried. I will give Schneider's results:—1. The presence of mercury was not shown by electrolysis in the urine of syphilitic patients, who had never been subjected to mercurial treatment; 2. Similar negative results were obtained on testing the urine of persons who had been previously treated with mercury. The investigations were made in cases in which the mercurial treatment had been employed 14 days, 5 months, and 6 months previously; 3. During the internal use of the mercurial preparations the urine always contained mercury; 4. The generally received opinion of the action of iodide of potassium on the metals which are retained in the body is by no means supported by the experiments of Schneider.

B. *Salts of the Alkalies.*—1. Alkaline carbonates always re-appear as such in the urine, although a portion of them is doubtless neutralised by the free acid of the gastric juice. They render the urine either neutral or alkaline. Free carbonic acid, effervescing wines, beer, and bicarbonates of the alkalies occasion an increased separation of oxalate of lime in the urine, the quantity of free carbonic acid being at the same time increased in it.

2. The ammonia of ammoniacal salts passes for the most part unchanged into the urine. I performed some experiments on this point in a young man, 20 years of age; he passed in 24 hours, as an average of twelve experiments, 0·6137 gramme of ammonia, corresponding with 1·9305 grammes of sal-ammoniac. 10 C.C. of a solution, which in the 10 C.C. contained exactly 2 grammes of sal-ammoniac, were taken in the evening with a glass of water, the urine carefully collected for 24 hours, and then subjected to analysis. The experiments were carried on for 5 days, and during this time 9·957 grammes of sal-ammoniac were secreted in place of the 10 grammes which had been taken. (See *Journ. f. Pract. Chemie*, Vol. 64, page 281.) Whether or not a portion of the ammoniacal salt is really converted into nitric acid in the body, as asserted by Dr. Bence Jones, is, at present, undecided.

The objections, however, taken by Lehmann to this opinion are not well founded, for sulphurous acid is not capable of decomposing hydriodic acid, nor consequently of forming iodide of starch. If, in the distillation, we make use of oil of vitriol for the separation of any nitric acid which may be accidentally present, we must previously free the sulphuric acid most carefully from the nitrogen-compounds, which are always present in it, and might, otherwise, occasion the nitric acid reaction.

3. Ferridcyanide of potassium appears again reduced to the state of ferrocyanide of potassium.

4. Rhodankalium passes rapidly into the urine, even when taken in small quantities.

5. Silicates, chlorates, and borates of the alkalies, when taken, reappear in the urine.

6. Iodide of potassium also passes into the urine, and may in most cases be readily discovered there by the starch-test.

7. Sulphide of potassium appears in the urine partly in the form of a sulphate, and partly unchanged.

c. *Salts of the Alkaline Earths.*—1. Soluble salts of baryta, when taken in tolerably large doses, may be found in the urine.

2. Salts of magnesia and lime do not pass into the urine, or, at least, only in very minute quantities.

II. *Organic Compounds.*

A. *Free Organic Acids.*—

1. Organic acids, such as oxalic, citric, malic, tartaric, succinic, and gallic acids, when taken into the body in a free state, pass unchanged into the urine, according to Wöhler.

2. *Acids of the Benzoic acid group.*—The changes which the class of acids, comprised under the head of the benzoic acid group, undergoes in the body, are interesting. It has been long known, that benzoic acid, as well as cinnamic acid, when taken into the body, reappear as hippuric acid in the urine. In like manner nitro-benzoic acid passes into nitro-hippuric acid in the body, and is separated as such with the urine. Kraut and Bertagnini have also succeeded in showing similar changes in the passage of toluylic acid and salicylic acid through the body.

The decomposition is the same in the case of all these acids, two equivalents of water being separated, and the elements of glycocoll ($C_4 H_5 N O_4$) taken up, as here shown:—

$$(1)\quad C_{14} H_6 O_4 + C_4 H_5 N O_4 - 2 H O = C_{18} H_9 N O_6$$

(Benzoic acid.) (Glycocoll.) (Hippuric acid.)

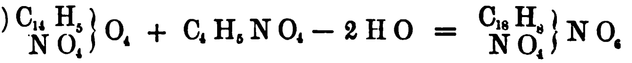
$$(2)\quad C_{14} H_6 O_6 + C_4 H_5 N O_4 - 2 H O = C_{18} H_9 N O_8$$

(Salicylic acid.) (Glycocoll.) (Salicyluric acid.)

$$(3)\quad C_{16} H_8 O_4 + C_4 H_5 N O_4 - 2 H O = C_{20} H_{11} N O_6$$

(Toluylic acid.) (Glycocoll.) (Toluric acid.)

(4)



$$(4)\quad \left.\begin{matrix} C_{14} H_5 \\ N O_4 \end{matrix}\right\} O_4 + C_4 H_5 N O_4 - 2 H O = \left.\begin{matrix} C_{18} H_8 \\ N O_4 \end{matrix}\right\} N O_6$$

(Nitrobenzoic acid.) (Glycocoll.) (Nitrohippuric acid.)

In addition to these, benzoic ether also produces hippuric acid. Oil of bitter almonds again is probably in the first instance converted into benzoic acid, and as such passes into the condition of hippuric acid. Lastly, it may be observed that benzoic acid, when taken internally, has been found by Lehmann unchanged in the sweat.

The other acids, which belong to the benzoic acid group, anisic acid, cumaric acid, and cuminic acid, appear, from experiments which have been made with them, to pass unchanged into the urine.

The changes which cinnamic acid ($C_{18} H_8 O_4$) goes through in the body, in passing into hippuric acid ($C_{18} H_9 N O_6$), were for a long time not well understood, but later researches into the constitution of this acid have now explained them. Chiozza, in his study of the anhydrous acids, observed, that cinnamic acid was split up into acetic acid and benzoic acid by the action of caustic potash.

$$\underset{\text{(Cinnamic acid.)}}{C_{18} H_8 O_4} + 4 HO = \underset{\text{(Acetic acid.)}}{C_4 H_4 O_4} + \underset{\text{(Benzoic acid.)}}{C_{14} H_6 O_4} + 2 H$$

Taking this fact as a foundation for his operations, Bertagnini attempted, and with happy results, the artificial formation of cinnamic acid,—premising that acetic acid and benzoic acid, grouped according to their atomic constitution, were present in it. The cinnamic acid was prepared by the action of chloracetic acid on oil of bitter almonds at 120° to 130° C. (248° to 266° Fahr.). There can, therefore, be no doubt that cinnamic acid is also decomposed into acetic acid and benzoic acid within the body, and that the benzoic acid subsequently appears in the urine in the form of hippuric acid.

The interesting researches of Kühne and Hallwachs prove, that the conversion of benzoic acid, &c., into hippuric acid, &c., only takes place when bile-constituents (glycocoll or glycocholate of soda) are present. I give from their work the following results:—

a. Benzoic acid or benzoate of soda, injected into the jugular or the crural vein passed away in great part unchanged with the urine.

b. Benzoic acid taken by the mouth passed unchanged into the urine, when the secretion of the liver was cut off.

c. The simultaneous injection of benzoic acid and bile, or glycocholate of soda, or pure glycocoll, into the blood, caused an abundant separation of hippuric acid with the urine. From this it follows, as might have been anticipated, that benzoic acid is only converted into hippuric acid in the blood, when glycocolate of soda, or pure glycocoll, is present there. The last experiment shows the possibility of the simple union of benzoic acid with glycocoll in the blood of the living body two equivalents of water (necessary for the formation of hippuric acid) being separated.

3. Tannic acid is converted into gallic acid, and again appears as such.

4. Camphoric acid is separated unchanged with the urine.

5. Uric acid undergoes the same decompositions in the body, as it does when acted upon artificially by peroxide of lead, or better

still, with permanganate of potash. When the body is perfectly healthy, and the respiration undisturbed, the uric acid, by taking up four equivalents of water, and six equivalents of oxygen, is in great part converted into urea and carbonic acid.

When the respiration is more or less impeded, in fact, even during sleep, oxalic acid, and under certain circumstances allantoine also, appear in the urine, as well as urea and carbonic acid, as products of decomposition of uric acid. Städeler and Frerichs indeed found allantoine present, when the respiration was artificially impeded.

We may consequently assume that the following equations represent correctly the decomposition of uric acid:—

1. Uric acid is decomposed by the addition of four equivalents of water, and six equivalents of oxygen, into carbonic acid and urea:—

$$C_{10}H_4N_4O_6 + 4\,HO + 6\,O = C_4H_5N_4O_4 + 6\,CO_2$$

(2 Eq. Uric acid.) (2 Eq. Urea.)

2. Uric acid, with the addition of four equivalents of water and four equivalents of oxygen, is converted into carbonic acid, oxalic acid, and urea:—

$$C_{10}H_4N_4O_6 + 4\,HO + 4\,O = C_4H_8N_4O_4 + 2\,C_2O_3 + 2\,CO_2$$

(2 Eq. Uric Acid.) (2 Eq. Urea.) (2 Eq. $\bar{O}$.)

3. Uric acid yields, with the addition of two equivalents of water and one equivalent of oxygen, allantoine and oxalic acid, which, by further oxidation, are also at last decomposed into urea and carbonic acid.

$$C_{10}H_4N_4O_6 + 2\,HO + O = C_8H_6N_4O_6 + C_2O_3$$

(2 Eq. Uric Acid.) (2 Eq. Allantoine.) ($\bar{O}$)

$$\bar{O}\ (C_2O_3) + O = 2\,CO_2$$

$$C_4H_3N_2O_3 + HO + 2\,O = C_2H_4N_2O_2 + 2\,CO_2$$

(1 Eq. Allantoine.) (1 Eq. Urea.)

B. *Salts of the Organic Acids.*—Neutral organic salts of alkalies are oxidised in the body, just the same as when they are burnt in oxygen. They appear in the urine as carbonates, rendering it alkaline, effervescing on the addition of acids, and causing a separation of the phosphatic earths. If they act as evacuants, or if they are taken with much animal food, we find that, in the first case, the urine does not become alkaline, and, in the second, only slightly so. Other circumstances, and especially diseased conditions of the body, influence the ordinary action of these bodies.

C. *Organic Bases.*—1. Quinine is readily found in the urine, when moderately large doses of it have been taken. According to Viale, tannic acid is a trustworthy test of the presence of quinine in the urine. The precipitate thrown down by tannic acid, when quinine is present, is very light, of a white colour, with a slight greenish tint. The precipitate when treated with a solution of chlorine in water, on addition of ammonia, assumes the green colour characteristic of salts of quinine. Viale has in this way succeeded in demonstrating the presence of quinine in the urine, in cases where only decoction of bark had been taken. (*Chemisch. Pharm. Centrbl.* 1853, p. 160.) Experiments on this point, made with rabbits, by my friend G. Kerner, show that the test is not always very distinctly marked, on account of the presence of the extractive matter, &c., which are thrown down with the quinine. Kerner, consequently, treated the precipitate which was obtained by the tannic acid, with milk of lime, allowed it to stand for a time, then separated the precipitate, and after washing, exhausted it with ethereal spirits of wine. The residue which remained, after the evaporation of the solution, showed most beautifully the quinine-reaction.

The following is the process given by Herapath for the same object: The urine is first of all rendered alkaline by potash, and shaken with ether, which takes up the quinine. The ether is then evaporated. A fluid test is prepared, consisting of three drachms of pure acetic acid, one drachm of rectified spirit, with six drops of diluted sulphuric acid. One drop of this mixture is placed on the object-glass, and a little of the ethereal residue added to it; next, a very minute quantity of an alcoholic solution of iodine is brought into contact with it, by means of a capillary tube. If quinine is present, a cinnamon-brown colour, occasioned by the formation of a compound of iodine with quinine, immediately appears; after a time sulphate of iodine and quinine, remarkable for its polarisation phenomena, is obtained, and may be recognised under the microscope. The sulphate of iodine and quinine crystallises in extremely thin plates, which may be substituted for tourmaline plates, on account of their exceedingly powerful polarising powers. Two plates, as thin as gold-leaf, as soon as they cross each other at right angles, prevent any light from passing through them. (*Journ. f. pract. Chemie*, Bd. 61, p. 87.)

2. Theine and theobromine cannot be discovered in the urine.

3. Aniline also was not found in it by Wöhler.

4. Alloxantine appears, according to Wöhler, to be decomposed into urea and other substances.

5. Allantoine does not pass into the urine, neither does it cause any increase of the oxalate of lime, but is probably converted, with the addition of two equivalents of oxygen, and one equivalent of water, into carbonic acid and urea. (See II, A. 5.)

6. Urea passes away unchanged with the urine.

7. Guanine causes a decided increase of urea, but when given in very large doses, passes away in part with the fæces.

8. Leucine injected into the blood appears again, in part, in the urine.

9. Amygdaline cannot be distinctly found again in the urine; but the urine contains, according to Lehmann and Ranke, an appreciable quantity of formic acid.

10. Salicine is decomposed, probably by oxidising agents; the urine contains hydride of salicyl, salicylic acid, saligenine, but neither sugar nor phenylic acid.

D. *Colouring and odoriferous matters.*—Most of these matters pass unchanged, or only very slightly modified, into the urine. Wöhler found in it the pigment-matter of indigo, madder, gamboge, rhubarb, logwood, rape, and bilberries; and besides these, the odours of valerian, garlick, assafœtida, castoreum, saffron, and turpentine. He did not find in it camphor, resin, empyreumatic oil, musk, alcohol, ether, lac red litmus, chlorophyll, and alkana colouring-matter.

SECOND PART.

SECTION XLIX.

QUANTITATIVE ANALYSIS.

In the preceding part I have spoken of the chemical and physical characters of the different constituents of the urine, whereby we are enabled to test the quality of the urine in the normal and abnormal conditions of the body. I now proceed to the consideration of the analytical methods at present employed in animal chemistry for the purpose of ascertaining the quantities of the different constituents present in the urine. The employment of the volumetrical method of analysis is of great value in all kinds of chemical investigations, but most especially in the analysis of the urine. It is only by this method that the practical physician is enabled in a short time to test, quantitatively, many of the constituents of the urine. I have, consequently, given especial attention to the description of this method of analysis.

SECTION L.

GENERAL REMARKS.

DETERMINATION OF THE QUANTITY OF URINE PASSED IN A GIVEN TIME.

It must be understood, that the determination of the quantity of urine passed in a given time forms the basis of all other quantitative investigations, and must therefore in no case be overlooked. Consequently, in all analyses of the urine, the quantity of the fluid and the time during which it is collected, must be taken into consideration. The quantity can be determined either by weight or measure; but measure is almost invariably employed for the purpose.

The cubic centimetre serves us as a standard of unity; one thousand cubic centimetres being equal to a litre, and one litre to a thousand grammes of water. When we have learnt the specific gravity of urine, whose quantity has been ascertained, we may readily arrive at a knowledge of its weight, by simply multiplying the number of ascertained cubic centimetres by the specific gravity of the urine. Thus 1000 C. C. of urine of 1·030 sp. gr. will weigh 1030 grammes. (For the determination of the specific gravity, see Sect. LI., 1.)

The urine is measured by means of graduated glass cylinders, with several of which of different sizes it is necessary that the operator should be provided.

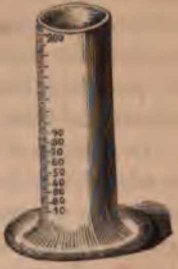
1. For determining the quantity of urine passed in twenty-four hours a measure is required, which will hold at least 2000 C. C. (2 litres); and this measure should be divided into parts containing 100 C. C. each. Such a measure is readily made, by pouring 100 grammes of water, carefully weighed, into a glass vessel of sufficient size, and marking the height at which the fluid stands with a file or a diamond; then weighing and adding another 100 grammes, and again marking the height, and so on, until the whole glass is graduated up to 2000 or 3000 C. C. This vessel may be used for the collection of the urine passed in twenty-four hours; it must, however, be carefully closed with a glass cover, around which a little lard, or what is better, a little wax, has been smeared, and kept in a cool place. The object of this is, in the first place, to prevent any evaporation of the water, and in the second, not to encourage the decomposition of the urine by warmth.

In using this vessel it is necessary to read off the quantity between each 100 C. C., which may occasion an error of 10 to 20 C. C. To prevent this, the urine must be put into another vessel, and then poured into the graduated vessel until it is filled up exactly to one of the marks; the remainder, a fraction of 100 C. C., must then be measured in a fine graduated cylinder.

2. For determining the quantity of urine passed in a shorter, but given time, finely gradulated cylinders (see Fig. 4) are required.

These should contain from 300 to 350 C. C., and must be subdivided into single C. C. In this way they serve for the exact determination of the quantity of urine passed during each hour.

FIG. 4.



The first or the second of these methods of collecting the urine will be adopted according to the particular object of the investigation; but it may be observed, that the collection of the urine, passed during the twenty-four hours, is most adapted for demonstrating extensive and chronic alterations in the secretion of urine; consequently the twenty-four hours' collected urine is generally employed in the analysis of the urine of the sick. The analysis of urine, however, which is passed at shorter intervals, enables us to seize upon temporary alterations of the secretion, and must necessarily be resorted to in the study of the action of those bodies which are only to be found temporarily in the secretion. (Vogel, *Archiv für Wissenchaftliche Heilkunde.* Göttingen, Heft. 1, p. 105.)

It must also be observed, that in all analyses of the urine, where a mean estimate of the contents is required, it is necessary to collect and analyse the urine passed during several consecutive days. From the results thus obtained the average may be estimated. (As to the quantity of urine passed during twenty-four hours under different circumstances, see Vogel's work above cited in *Archiv,* &c.)

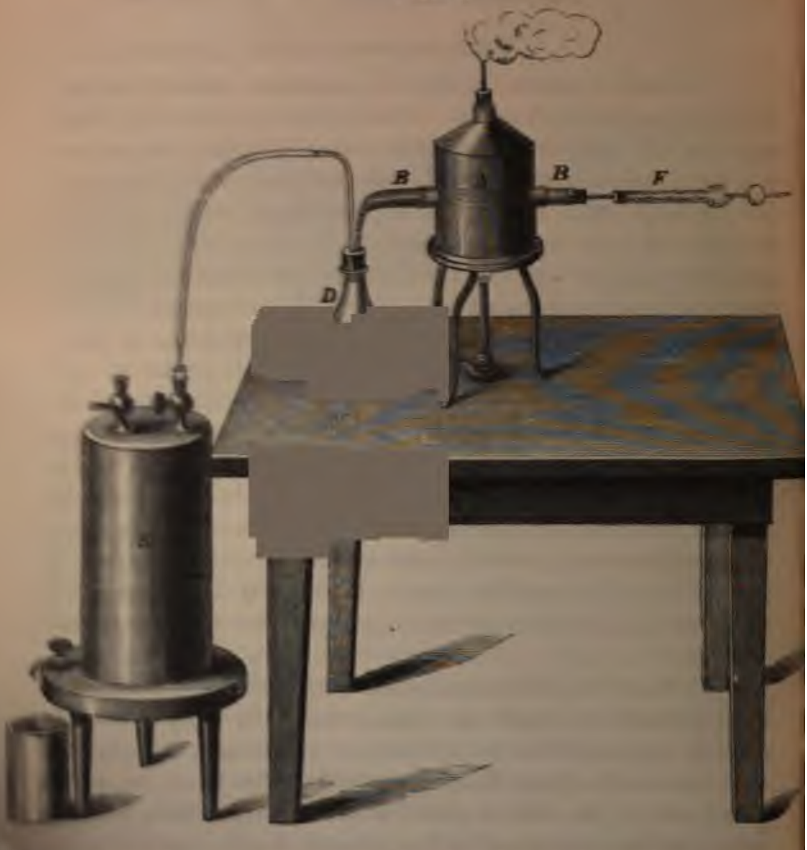
SECTION LI.

SPECIFIC GRAVITY.

1. *Specific Gravity taken by the Urinometer.*—We can obtain only an approximative knowledge of the true specific gravity of the urine by the aid of the urinometer. This instrument is, nevertheless, well adapted for the purposes of the practical physician. A special instrument, called the Urinometer, has been constructed for the determination of the specific gravity of the urine, of a character similar to those employed for determining the specific gravity of alcohol,

which is closed by a cork covered with tinfoil. Two cubic centimetres of urine are then poured, by means of a pipette, containing

FIG. 12.



precisely that quantity, upon the glass fragments in the porcelain boat. The boat is then carefully introduced into the tube, B B, hich is already connected with flask, D. The flask, D, conins 10 C. C. of standard sulphuric acid, and is brought into connexion with the aspirator, E. The glass tube is then carefully dipped into the tin pipe inside the water-bath, and the other end of it closed with the chloride of calcium tube, F,—the glass tube being nly with the left hand whilst the cork is pressed in with the hen the water in A boils, the cock of the aspirator is opened (it having been previously ascertained that the apparatus is perfectly air-tight), and the water allowed to flow out in such quantity as to cause the air which is dried in F to pass up, bubble by bubble, through the sulphuric acid in D.

In this way the urine is completely evaporated in a thoroughly dry atmosphere at 100° C. (212° Fahr.). The evaporation is completed in three quarters of an hour, but as the urine-residue tenaciously retains some water, it is necessary to continue the heat a short time longer. The glass fragments greatly promote the desiccation, which may be considered as complete in about three hours. The current of air is then cut off, the chloride of calcium tube removed, the glass tube drawn out of the water-bath, and the porcelain boat again slipped into the tube in which it was weighed before the desiccation, and at once closely corked-up. When thoroughly cooled in the exsiccator (Fig. 11) the tube is weighed. The product gives the amount, thus directly obtained, of the residue of 2 C. C. of urine.

We next ascertain the quantity of ammonia which has been evolved. The carbonate of ammonia, which in most cases is sublimed in the tube that carries off the vapour, is washed into the flask, the cork removed, and the bent limb of the tube which dips into the flask also washed by means of a syringe. One or two drops of tincture of litmus are then added, the contents of the flask heated to boiling, in order to drive off the carbonic acid, and the acid, which is not yet saturated, treated with standard solution of caustic soda. We can then at once reckon the quantity of urea by the amount of caustic soda employed. This quantity added to the sum of urine-residue, directly obtained, gives the entire quantity of solid constituents contained in the urine.

The standard sulphuric acid used for this purpose contains 2·667 grammes of sulphuric acid in a litre. Consequently 1 C. C. of it will be saturated by 0·0011335 gramme of ammonia, which corresponds with 0·002 gramme of urea. If then to this sulphuric acid caustic soda be added, of such strength that 1 C. C. of the sulphuric acid suffices for the exact saturation of 2 C. C. of the soda, each cubic centimetre of the soda, less than twenty, which has been used in the saturation of 10 C.C. of sulphuric acid, will correspond with exactly one milligramme of urea. For example:—

The 2 C. C. of urine in the porcelain boat yielded 0·10 gramme of solid residue. At the end of the process 10 C. C. of sulphuric acid employed required 16 C. C. of caustic soda; consequently 4 C. C. have of the urine. By dividing its absolute weight thus ascertained, by the known weight of the distilled water, we obtain as quotient the specific gravity. If for example:—

The bottle filled with distilled water weighs 80 grammes,
and the empty bottle weighs 30 grammes,
the bottle contains of water 50 grammes.

If the bottle filled with urine weighs 81·2 grammes,
and the empty bottle weighs 30·0 grammes,
the bottle will contain of urine 51·2 grammes.

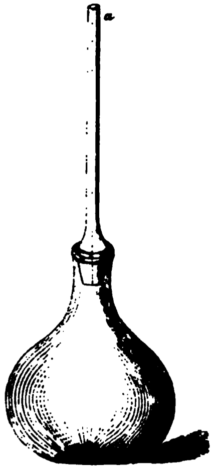
The sp. gr. of water = 1·000.

Hence we have the equation:

50 : 51·2 = 1·000 (sp. gr. of water) :: x (sp. gr. of urine).

$$\frac{51{\cdot}2 + 1{\cdot}000}{50} = 1{\cdot}024.$$

FIG. 6.



Instead of an ordinary bottle, we may more advantageously make use of a piknometer arranged for the purpose (Fig. 6). This kind of bottle is easily weighed, contains a tolerably large quantity of fluid, and does not permit of any air-bubbles being enclosed in it, the air escaping through the fine capillary canal of the glass tube which is inserted into the bottle. A well-made piknometer also contains in this tube a small thermometer, which allows the temperature to be ascertained at the same time. The method of using it is the same as that above described; the weight of distilled water which the piknometer will contain having been definitively ascertained.

SECTION LII.

DETERMINATION OF THE QUANTITY OF THE WATER AND OF THE SOLUBLE SUBSTANCES IN THE URINE.

1. We have many difficulties to encounter in determining the amount of solid residue of urine, arising from the ready decomposition of the fluid, and also from the extremely hygroscopic character

of its residue. The first or the second of the following methods may be adopted, according as greater or less accuracy is required in the analysis.

1. 10 to 15 grammes or cubic centimetres of urine are weighed or measured in a smallish porcelain crucible (Fig. 7), which has been carefully weighed, and is covered with a lid, and are then evaporated to dryness in a water-bath. Instead of a crucible, a small glass cup (Fig. 8), having a ground border, and which is capable of being hermetically closed by a flat plate of glass, may be advantageously employed. Of course, the solid residue must not be raised to a red-heat in this vessel. (Sect. LIII.)

FIG. 7.

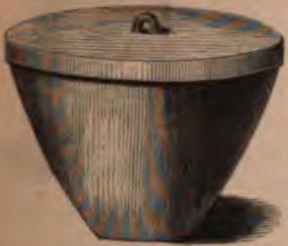


FIG. 8.

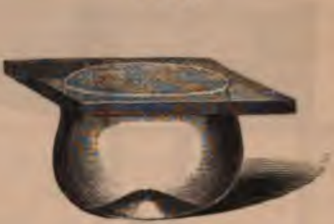
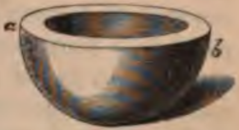


Figure 9 represents a water-bath suitable for the purpose of carrying on evaporation. It is formed of strong copper-plate, and when used is half-filled with water, which is boiled by means of a small spirit-lamp. In order to carry on evaporations in cups and crucibles of different sizes, rings of corresponding sizes may be laid upon this copper-bath. It has from *a* to *b* a width of from four to six inches.

FIG. 9.



The residue thus obtained is not entirely deprived of water, and must therefore be still further dried, at a temperature of 100° C. (212° Fahr.) For this purpose an air-bath of the kind here represented (Fig. 10) may be used. On the wire-stand, *e*, the crucible containing the residue of the evaporation is placed, and the apparatus is then heated beneath by a small spirit-lamp. The temperature is determined by means of a thermometer, *d*, which is introduced through *c* by means of a cork, and may be easily maintained at nearly a constant rate.

When the residue of the urine has been thus dried for half-an-hour, or an hour, the crucible is covered with its lid, and allowed to cool in a glass containing concentrated sulphuric acid. If allowed to cool in the air, the contents of the crucible would rapidly re-absorb moisture from the air. Figure 11 shows an apparatus adapted for this purpose. The crucible is placed upon lead wire, *b*, raised above the acid; and the vessel is then hermetically closed with a well-fitting glass plate, greased at the borders. From this vessel the crucible is removed, and immediately weighed. It is then once again exposed to a temperature of 100° C. (212° Fahr.), and weighed a second time, and if it has not lost anything more in weight the operation may be considered as complete. The quantity of solid residue contained in the whole quantity of urine, may now be ascertained by deducting the weight of the crucible.

Fig. 10.

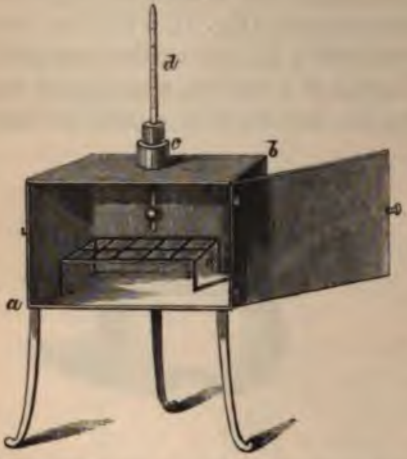
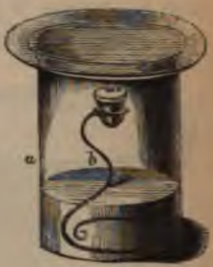


Fig. 11.



If, further, the weight of the residue is subtracted from that of the whole quantity of urine operated upon, we obtain the amount of evaporated water.

For example:—

I. The quantity of urine passed in twenty-four hours = 1000 C. C. of 1·024 sp. gr. 10 C. C. are evaporated to dryness, and the residue dried at 100° C. (212° Fahr.).

The crucible with the residue = 24·580 grammes.
The crucible only = 24·350 grammes.
The residue = 0·230 gramme.

SECTION LIV.

DETERMINATION OF THE COLOURING-MATTER OF THE URINE.

The process here given is that described by Vogel; we may therefore rest assured that it is well adapted for the purposes of the physician. (*Archiv zur Förderung wissenschaftlicher Heilkunde,* 1853. Heft. 1, p. 137.)

A. *Table of colours.* (See the appended Table.)

Vogel succeeded, after making a large number of observations, in assigning to the different shades of colour, both of normal and of abnormal urine, its appropriate character. He accomplished this by forming artificial colours with a mixture of varying quantities of gamboge, lake-carmine, and Prussian blue. He distinguishes three groups or shades of colour.

Group I. *Yellow Urine.*

The colour is a yellow (gamboge) more or less diluted with water. This group contains three varieties of colour, whose starting-point is completely colourless urine, which is very seldom met with.

1. Pale Yellow (gamboge with much water),
2. Bright Yellow („ with little water),
3. Yellow („ with very little water).

Group II. *Reddish Urine.*

More or less red is mixed with the yellow (gamboge, with lake-carmine).

Urine of this kind is distinguished by the common phrase of "high"-coloured. Three shades of colour also fall under this head:—

4. *Reddish-yellow.*—A little red is mixed with the yellow, the yellow prevailing (gamboge, with a little lake-carmine).

5. *Yellowish-red.*—The red colour more distinctly mixed with the yellow (gamboge, with more lake-carmine).

6. *Red.*—The red prevailing, but a little yellow still mixed with it (lake-carmine, with a little gamboge).

Group III. *Brown* (*dark*) *Urine.*

The red colour passes through brown, almost into black (gamboge, lake-carmine, with more or less Prussian blue).

7. *Brownish-red.*—A little brown mixed with the red.

8. *Reddish-brown.*—Browner than last.

9. *Brownish-black.*—Almost black, but with a tendency to brown.

A practised eye can distinguish intermediate shades between these varieties of colours, so as, for example, to be able to determine that the colour is intermediate between bright-yellow and yellow; or that it approaches nearer to the reddish-yellow than to yellowish-red, and so on. According to Vogel, however, the nine shades above given suffice for all practical purposes.

B. *Indication of these shades of colour.*—The varieties of colour correspond with certain variations in the quantity of the colouring-matter of the urine. It has for instance been found, that by diluting a higher number with water, all the numbers below it may be produced. Thus all the nine varieties of colour form one series, and the colouring-matters of the urine may be considered as merely different degrees of dilution of one and the same pigment-matter; from this category, however, must naturally be excluded accidental colouring-matters, such as bile-, drug-, or food-pigments, which are only occasionally met with. These experiments, quantitatively considered, show that urine diluted with an equal quantity of water, produces almost the very same shade of colour with that standing immediately below it in the scale; 200 C. C. of urine, for instance, of yellowish-red colour, diluted with 200 C. C. of water, thus become of a reddish-yellow colour, &c. This relative connexion holds good in all divisions of the scale, so that it may be made use of to determine quantitatively the relative amount of pigment-matter in different urines.

The following Table will serve for such an analysis:—

I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	
1	2	4	8	16	32	64	128	256	Pale yellow = I.
—	1	2	4	8	16	32	64	128	Bright yellow = II.
—	—	1	2	4	8	16	32	64	Yellow . . . = III.
—	—	—	1	2	4	8	16	32	Reddish-yellow = IV.
—	—	—	—	1	2	4	8	16	Yellowish-red = V.
—	—	—	—	—	1	2	4	8	Red . . . . = VI.
—	—	—	—	—	—	1	2	4	Brownish-red = VII.
—	—	—	—	—	—	—	1	2	Reddish-brown = VIII.
—	—	—	—	—	—	—	—	1	Brownish-black = IX.

C. *Use of this table.*—This Table serves for the quantitative comparison of the amount of urine-pigment passed with the urine; it tells us what is, comparatively, the quantity of colouring-matter contained in equal quantities of urine of different shades of colour. If, for instance, a given quantity of pale-yellow urine contains 1 part of colouring-matter, a like volume of yellowish-red urine will contain

16 parts, of red 32 parts, of brownish-black 256 parts, &c. of colouring-matter. Moreover, 1 volume of yellow urine will contain as much colouring-matter as 4 volumes of pale-yellow, 1 volume of red as much as 4 volumes of reddish-yellow, as 32 volumes of pale-yellow, and so on. If, therefore, one person passes 1000 C. C. of yellow urine in twenty-four hours, and another person passes 4000 C. C. of pale-yellow urine in the same time, they will both pass an equal quantity of colouring-matter.

In order to establish an approximative comparison in figures, Vogel sets down the quantity of colouring-matter contained in 1000 C. C. of pale urine as = 1.

In comparing the colour of the urine with the table of colours, we must take care that the urine is perfectly clear—in most cases it will require filtering—and that the light in which we observe it should pass through a layer of urine four to five inches thick; otherwise the results obtained will not be uniform. For this purpose glasses from four to five inches in diameter, and containing 800 to 1000 C. C. should be employed. If the thickness of the layer of fluid be less, the colours will be comparatively paler than those given in the Table.

Example:—

1800 C. C. of yellow urine are passed in twenty-four hours.

1000 C. C. of pale-yellow urine = 1 part of colouring-matter, but yellow urine, according to the Table, contains four times as much; consequently we obtain the following proportion:—

1000 : 4 = 1800 : x = 7·2 = the quantity of colouring-matter in 1800 C. C. of yellow urine—the colouring-matter in 1000 C. C. of pale-yellow urine being taken as 1.

SECTION LV.

DETERMINATION OF THE QUANTITY OF THE INDIVIDUAL CONSTITUENTS OF URINE.

The Volumetrical Method.

By the adoption of this method of calculation, the analysis of the urine is greatly simplified, and much more quickly accomplished. In determining the weight of any substance by volumetrical analysis we do not proceed, as in the ordinary way, by collecting and weighing it after its precipitation. What we do is this: we learn the quantity of the substance present by calculating the exact amount of the reagent, which is employed and required for the completion of the reaction. Estimations by this method, which are thus wholly founded on a determination of the amount of the soluble test used, require for their success, the exact fulfilment of the following conditions:—

1. The strength of the reagent in solution must be accurately known, as well as the quantity of the volumetrical solution employed.

2. The point at which the reaction ceases, that is, when the exact amount of the volumetrical solution necessary for its completion has been added, must be indicated in a way distinctly manifest to the eye.

3. The decomposition, on whose completion the analysis depends, must be in all cases the same.

4. The decomposition must be so conducted, that no part, either of the agent acting or of the substance acted on, shall be lost.

As these conditions vary in different instances, no general directions, applicable to all cases, can be given for their fulfilment. We shall, therefore, explain them more particularly when treating separately of the different substances employed in the analysis. We must, however, in the first place give a general description of the apparatus required in the performance of this method of analysis.

SECTION LVI.

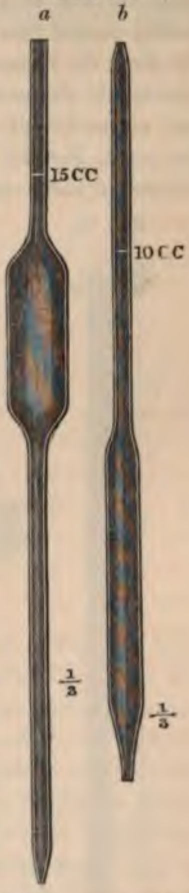
APPARATUS.

The French system of weights and measures, on account of its general excellence, is invariably employed in all quantitative chemical analyses. There is in this system an intimate relation between weight and volume; 1000 C. C., for example, of water = 1 litre of water taken at its greatest density, that is at + 4° (39° Fahr.), weigh exactly 1 kilogramme, or 1000 grammes. Consequently, one cubic centimetre corresponds exactly to one gramme.

All the measures employed in volumetrical analysis are divided into cubic centimetres. Of these we may mention:—

1. *The graduated pipette.*—It is made of glass; and its form is shown in Fig. 14, *a. b.* It serves us for measuring the fluid which is to be investigated; and when filled to the neck, where it is marked, contains 50, 20, 15, 10, 4, or 3 cubic centimetres. In using it its point is introduced into the fluid, and suction made until the fluid has risen above the level of the mark in the neck; the upper opening is then closed with a moist finger—neither dry nor wet,—the pipette dried outside to remove any adherent fluid, and the finger slightly raised to admit a little air, and to allow the fluid to escape until it reaches the level of the mark, the surface of the fluid being kept on the same level as the eye. When the fluid has fallen to this point, the pipette is again firmly closed with the finger, and its contents may now be allowed to run out into any convenient vessel.

FIG. 14.



The mode of graduating the pipette is a matter of great importance, for it depends upon this, whether the last drops which collect in the lower opening of the instrument, and can be removed by blowing into the pipette, are to be employed or not. The most correct and useful are those called *Pipettes à l'écoulement,* which are so graduated as to allow the measured quantity of fluid to flow out in one stream, so that there is no necessity for blowing out the last drops from the nozzle of them. In all cases it is best to bring the point of the pipette against the moist side of the glass, while the fluid is escaping from it. This method of measuring gives the most uniform results; but it is evident that the pipettes must be graduated expressly for this kind of measurement. For analysis of the urine, and in order to be prepared for all cases, pipettes containing 50, 30, 15, 10, 4, and 3 C. C. are required.

The following apparatus serves for measuring the volumetrical solutions:—

2. *Mohr's pipette.*—This pipette is graduated throughout its

whole length, and contains from 30 to 40 C. C.; each centim again, is subdivided into 10 parts, representing the $\frac{1}{10}$ C. C. (Fig. 1 They are not drawn out at the upper part, but permit fluids to readily poured into them, the opening being then closed with a c To allow the volumetrical solution to flow drop by drop out of pipette, the following extremely simple arrangement is resorted and serves for all purposes of this kind: A glass tube drawn t fine point, Fig. 16, *d*, is fixed into the lower end of a short piec vulcanised india-rubber tubing, Fig. 16, *a a*, which is compressed

FIG. 15.

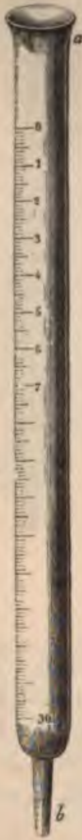


FIG. 16.

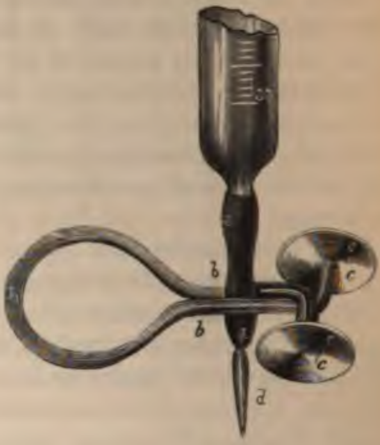
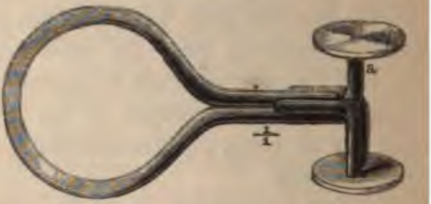
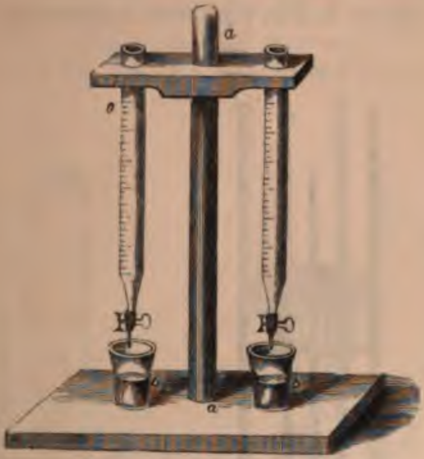


FIG. 17.



hermetically closed by the clip, *b b*, Figs. 16 and 17. This clip is arranged as to be opened by pressing upon the two plates, *c c*. T a-rubber tube is slipped over the nozzle, *b*, of the pipette, Fig. nd the pipette fixed, by means of a cork, into a wooden frame, to hang down perpendicularly. Fig. 18 represents the appa- complete.

FIG. 18.



using it, the pipette is filled up to the mark *o*, Fig. 18, with volumetrical fluid, the urine to be tested measured out into the er-glass, *b*, and the volumetrical solution then allowed to run by pressing on the clip, and towards the last to drop into it, until proper quantity has been added. By this ingenious arrangement secure both a rapid flow of the fluid, and also its flow in single s. In investigations which require some time for their com- on, two or more of these are employed; when completely or filled, they are fixed in the stand and there left, their upper ing being closed with a cork to prevent evaporation.

n apparatus of this description, which is very convenient for the oses of the physician, is represented in Fig. 19; its use is readily rstood. *a b*, on which the eight arms are fixed, is a short cylin- of brass sustained by a screw, and readily moved on its axis. ve, the pipettes are held in their places by spring clasps, but w are simply received in a conical holder, furnished with a e, in order to allow of the more ready removal of the pipette; *c c c* ieces of card-paper, fixed on to each arm by means of a small clamp; these cards indicate the nature of the fluid in the pipettes; *d* is a platform, resting upon four screws, which serve for perpendicular adjustment of the whole apparatus. By enlarging the apparatus, six to eight pipettes may be easily fixed in it.

For the same purpose serves also:—

3. *The graduated burette.*—The ordinary form of this ingenious instrument is shown in Fig. 20. The narrow tube serves for the exit of the fluid, and must therefore be placed somewhat below the level of the opening of the larger tube in order to allow of the ready escape of the fluid. These burettes contain, either 30 C. C., and are in such case divided, like the pipette, Fig. 15 into $\frac{1}{10}$ C. C., or they contain 50 C. C., and are then divided into 100 parts, each of which contains ½ C. C. When used, they are filled up to a little above the

Fig. 19.

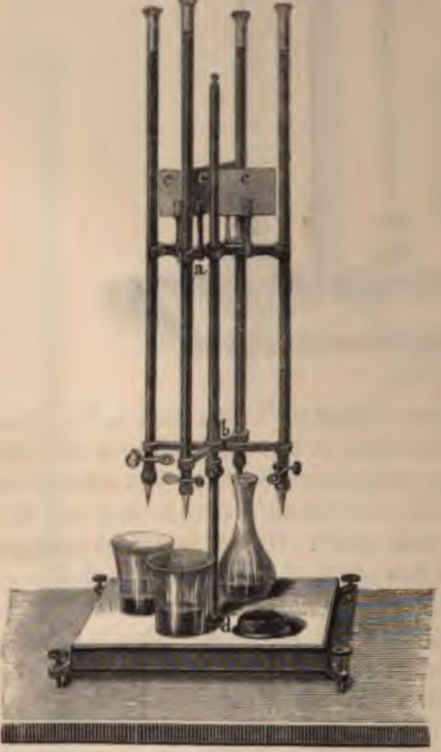
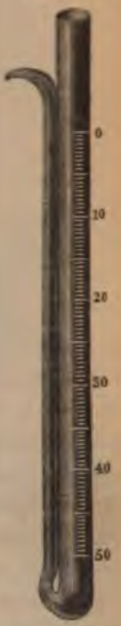


Fig. 20.



t *o* with the volumetrical solution, and the excess then allowed
scape through the narrow tube, until the level of the fluid is
id to be exactly at *o*. Mohr's apparatus, above described, render
instrument, which is readily broken, superfluous. Mohr's pi-
e, as well as the burette, must be graduated *à l'écoulement.*

. *The graduated cylinder* serves for the preparation of the volu-
rical solutions, and is represented in Fig. 21. It should hold from
to 600 C. C., and be marked off at every 5 C. C. Graduated
ks, as shown in Fig. 22, also serve for the purpose; when filled

FIG. 21.

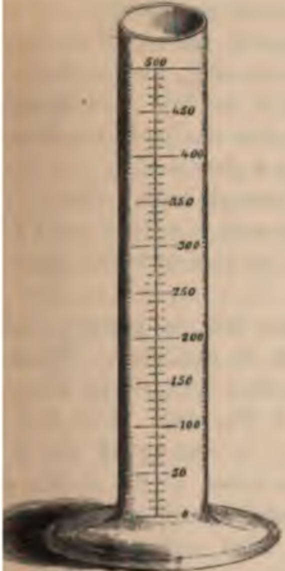
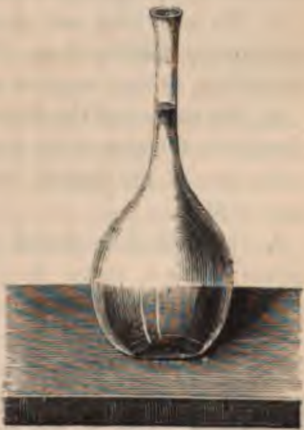


FIG. 22.



to a certain mark in the neck, they should contain 1, ½, or ¼ of a
e. For the preparation of the volumetrical solutions these flasks
preferable to the cylinders.

ll the instruments here spoken of may be obtained, of great ex-
tude, from Niemann, of Alfeld, in Hanover.

SECTION LVII.

MODE OF PROCEDURE.

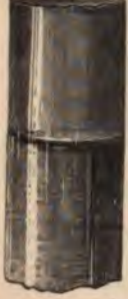
In carrying out the volumetrical method of analysis we must, as already remarked, pay the greatest attention to the preparation of the solutions required for the purpose, for upon these solutions the correctness of the analyses essentially depends. Special rules for this object will be given under the head of each particular process. We may, however, remark, that the solutions must always be prepared and used at a given temperature, as their volume varies considerably under the action of heat. Great care is also required in reading off the level of the fluid in the different kinds of measures used; for instance:—

1. We must take care that the level of the fluid is not interfered with by any bubbles of air. We must allow the bubbles to break of themselves, or they must be removed by a glass rod.

2. The surface of the fluid must be perfectly level. This point is obtained in the case of the pipette by allowing it to hang freely; but, in the case of the burette, best of all, by placing it flat against a pane of glass.

3. When fluid is poured into a narrow tube, we observe, that its surface forms a curve, in consequence of capillarity. When we examine this curve, especially by transmitted light, several zones are readily distinguished in it (Fig. 23). Now, it is not a matter of indifference, in reading off the scale, whether the upper, or the lower, or the middle portion of the curve corresponds with the graduation. The measurements are most accurate, when (the pipette or the burette having been placed in a perpendicular position) the eye is brought on to a level with the under border of the dark zone, and the graduation of the fluid corresponding with it then read off. This border is most distinctly marked and seen by transmitted light.

FIG. 23.



$\frac{1}{1}$

When the urine to be tested has been measured, and the pipette or the burette filled with the volumetrical solution, we first of all allow the solution to run slowly out, and at last drop by drop into the urine, until the operation is completed. When the point of completion is shown in all parts of the fluid, by some distinct reaction, we are sure that the process followed is good; but if this be not the case, then we must test the mixture again and again towards the conclusion of the experiment, until the right point has been attained. Each process has, in this respect, its own particular mode of reaction, and must, therefore, be separately provided for. When the addition of the volumetrical solution is duly accomplished, we ascertain the volume of the fluid which has been used—taking the precautions above laid down—and from this we calculate the quantity of the substance sought for in the urine.

If, for example, in ascertaining the quantity of urea in 10 C. C. of rine, we use 20 C. C. of the solution of mercury, each C. C. of which xactly corresponds with 10 milligrammes of urea, it follows: that in he 10 C. C. of urine (20 × 10) there are 200 milligrammes of urea, nd therefore in 1000 C. C. 20·00 grammes.

In using the burette, care must be taken, not to hold it too much n one side so as to allow the fluid to escape out of the broad ibe. This readily happens, if a drop of the fluid should remain ehind in the narrow end of the tube, and prevent the flow of the uid. This accident may be prevented by blowing into the tube.

By volumetrical analysis we can determine the quantity of chlorine, urea, of phosphoric acid, of free acids, of sulphuric acid, of lime, ammonia, and of sugar in the urine.

SECTION LVIII.

DETERMINATION OF THE QUANTITY OF CHLORINE IN THE URINE.

CHLORIDE OF SODIUM.

Liebig's method with Proto-nitrate of Mercury.

A. *Theory.*—The principle upon which this excellent volumetrical rocess is founded has already been spoken of under the head of Chlo- de of Sodium (Sect. XI. 4). We need, therefore, here only remind ie reader, that in a solution of chloride of sodium which contains rea, a permanent precipitate of urea and oxide of mercury is not rmed by a solution of nitrate of mercury until the whole of the chloride of sodium present has been decomposed, and the nitrate of mercury consequently converted into corrosive sublimate. When the chloride of sodium is thus completely decomposed, the very next drop of the solution of mercury which is added will throw down a permanent deposit of oxide of mercury and urea.

One equivalent of chloride of sodium (one equivalent of chlorine) corresponds with one equivalent of nitrate of mercury; if, therefore, we know the quantity of mercury in the solution of nitrate of mercury that has been added to the solution of urea containing chloride of sodium—the quantity of chloride of sodium in the mixture being unknown—we at once learn the quantity of chlorine or chloride of sodium which was contained in the solution. Of course it is understood that the nitrate of mercury solution is added, as above enjoined, only up to the point when a permanent precipitate begins to fall.

For this process the following solutions, whose preparations are here given, are required:—

B. *Preparation of the solutions.*—1. *Standard solution of chloride of sodium.*—This solution must contain exactly 0·200 gramme in 10 C. C., or 20 grammes of salt in 1000 C. C. (one litre); it is readily prepared by dissolving 20 grammes of pure fused chloride of sodium in water and then diluting the solution up to 1000 C. C. We can also obtain a solution which contains a constant quantity of the salt, by pouring water over lumps of pure transparent rock-salt, and allowing it to stand for twenty-four hours, at a temperature between 12° and 24° C. (53° and 75° Fahr.), (frequently shaking it during that time). According to Liebig's, Fehling's, and my own observations, 10 C. C. of this clear filtered solution contain 3·184 grammes of chloride of sodium.

If now we measure out, by means of the pipette, and with the precautions above given, 20 C. C. of this solution of salt, and dilute it up to 318·4 C. C., we shall find that it contains altogether 6368 milligrammes of chloride of sodium, and therefore, exactly 200 milligrammes of salt, in 10 C. C.

2. *Solution of urea.*—This solution must contain 4 grammes of urea in 100 C. C., and, consequently, 40 milligrammes in 1 C. C. It is prepared by weighing out 4 grammes of urea, dissolving them, and diluting them up to 100 C. C.

3. *Standard solution of proto-nitrate of mercury.*—This solution must contain 17·06 grammes of mercury in a litre; so that 1 C.C.

of it will exactly correspond with 10 milligrammes of chloride of sodium.

a. Preparation of the proto-nitrate of mercury.—Great care is required in its preparation, as it must be absolutely free from all admixture with bismuth, lead, silver, and suboxide of mercury.

17·06 grammes of chemically pure mercury are weighed and introduced into a beaker-glass, which is then covered with a large watch-glass, and heated with strong nitric acid, free from chlorine, so long as any nitrous acid vapour is given off, and until a drop of the fluid tested with chloride of sodium ceases to show any cloudiness from formation of subchloride of mercury. The solution of oxide of mercury thus obtained is evaporated to a syrup in a water-bath, and then diluted with water up to a litre. Should any basic salt separate in the process, a drop or two of nitric acid will at once effect its disappearance. This solution must then be tested with the standard chloride of sodium (1), in order to try its purity.

Pure mercury is not to be bought in the market, and if the operator possesses none, he may prepare it from crystals of subnitrate of mercury, which are obtained by heating an excess of mercury with dilute nitric acid, and by concentration and cooling of the solution. The crystals are separated from the impure mother-liquor, washed with a little dilute nitric acid, then with water, and dissolved in nitric acid, and, as before, converted into an oxide. The solution, evaporated to a syrup in the water-bath, is diluted with ten times its volume of water. If in the course of twenty-four hours any basic salt is separated from this mixture, it may be removed by filtration. This process is much to be preferred to the first, for mercury can rarely be obtained pure enough for the purpose required, and a small admixture of other metals in it causes very considerable disturbances in volumetrical analysis, so as in fact to interfere greatly with the final results, and in some cases to render correct calculation impossible.

The quantity of oxide contained in the solution must now be determined, that is to say, the solution must be graduated—rendered volumetrical.

b. Graduation of the solution of mercury.—The graduation may be effected in two ways, either directly with a solution of pure chloride of sodium of known strength (solution of chloride of sodium, 1);

or the quantity of oxide of mercury may be first ascertained, and the solution then diluted with water, so as that one litre shall contain 17·06 grammes of mercury. One cubic centimetre of this solution corresponds with 10 milligrammes of chloride of sodium, or with 6·065 milligrammes of chlorine. For the second process a peculiar method of graduating mercury, has been proposed by Liebig, which I will explain in the next paragraph.

The graduation with the solution of chloride of sodium is performed in the following manner:—

10 C. C. of the standard solution of chloride of sodium (1) is measured off by a pipette into a small beaker-glass; 3 C. C. of the solution of urea (2), and 5 C. C. of a cold saturated solution of pure sulphate of soda are then added to it. Mohr's pipette, or the burette, is now filled in the manner above described (Section LVI.) with the dilute solution of mercury, which is then allowed to flow out by drops into the solution of urea and chloride of sodium, the mixture being continually agitated. As soon as a distinct and permanent precipitate appears in the fluid, the test is complete. A mere opalescence of the fluid is not a sufficient sign of the completeness of the reaction, for it may depend upon the accidental presence of a trace of foreign metals, and is, in fact, very different from the suddenly-formed and cloudy precipitate, which indicates the formation of the compound of urea and mercury, and the completion of the analysis.

The solution of mercury must not be too concentrated; if, for example, 7·5 C. C. of the solution of mercury have been used, it will be found, that it is too concentrated to give accurate results. It must, therefore, be diluted with an equal volume of water, and the test applied a second time. If we now find, that 15·5 C. C. of the solution of mercury are necessary to produce the cloudiness desired in 10 C. C. of the solution of chloride of sodium and urea, we must add

to every 155 C. C. of solution of mercury
45 C. C. of water,

whereby we obtain 200 C. C. of a solution, of which 20 C. C. indicate exactly 200 milligrammes of chloride of sodium, or 1 C. C. 10 milligrammes of chloride of sodium, or 6·065 milligrammes of chlorine. A counter-test should be applied to show, that exactly 20 C. C. of the solution of mercury are required to produce a distinct cloudiness when the last drop of it is added to the above 10 C. C. of normal solution of chloride of sodium (= 0·200 gramme). The degree of this cloudiness must be carefully noted, otherwise, in the quantitative analysis of the urine the solution of mercury may be added, so as at one time to produce a considerable degree of cloudiness, and at another time only a slight cloudiness; and hence give rise to error in the calculation. By a little practice, however, the exact degree of cloudiness required is learnt.

It must be observed, that the compound of urea and mercury is somewhat more soluble in dilute nitric acid than in pure water, and again more soluble in water than in a solution of nitrate of urea. As then the urine contains more of urea than what corresponds with the quantity of graduated solution of chloride of sodium which had been added, nitrate of urea is formed in consequence of nitric acid being set free; and the solubility of the compound of urea and mercury is thereby lessened. Consequently, in graduating the solution of mercury with the solution of normal chloride of sodium, which contains no foreign salts, and only a small quantity of urea, we must add a slight excess, because the first traces of the precipitate are dissolved by the nitric acid which has been set free. For this purpose in the graduation of the solution of mercury we add to the solution of chloride of sodium 5 C. C. of a saturated solution of sulphate of soda, whereby acid sulphate of soda is formed. This salt of soda, like the nitrate of urea which is formed in the urine during the graduation-process, lessens the solubility of the mercury and urea compound, and thus diminishes the error which might otherwise arise.

4. *Solution of baryta.*—This is prepared by the admixture of one volume of a cold saturated solution of nitrate of baryta with two volumes of an equally cold saturated solution of baryta.

c. *Process.*—In order to determine the quantity of chloride of sodium in the urine, the phosphates contained in it must be first of all removed; and this is accomplished by the baryta-solution (4). Of this solution 20 C. C. are mixed with 40 C. C. of urine, and the precipitate removed by filtration—the filter not being previously moistened. If the filtrate is alkaline, it must be carefully saturated with nitric acid, until in fact the fluid shows signs of a very feeble acid reaction. An excess of nitric acid materially interferes with the results.

For experimental purposes, 15 C. C. of this fluid, which correspond with 10 C. C. of urine, are measured off by a pipette, which contains exactly this volume without any subdivisional measuring, and the fluid is run off into a beaker-glass. The standard solution of mercury (3) is then added to it from Mohr's pipette, or from a burette, until the distinct permanent cloudiness appears. When this point is attained, the number of cubic-centimetres employed is read off. Each cubic centimetre corresponds with 10 milligrammes (0·010) of chloride of sodium, or 6.065 milligrammes of chlorine; and, in this way may be calculated the whole quantity of chlorine contained in the urine.

Example:—

15 C. C. of the above mixture = 10 C. C. of urine required, for the production of the proper permanent cloudiness, 15 C. C. of the solution of mercury, which correspond with 150 milligrammes (0·150) of chloride of sodium in 10 C. C. of urine. 1000 C. C., therefore, contain 15·00 grammes.

For the modification of this process, required when albumen is present in the urine, see Urea. (Section LX. D.)

The Method with Nitrate of Silver.

A. *Theory.*—The principle of this method is readily explained. A graduated solution of nitrate of silver is added to the urine after it has been filtered and rendered acid with nitric acid, so long as a precipitate is formed by it; it is, however, difficult without filtration, which renders the operation somewhat inconvenient and inexact, to hit the exact point of saturation. Mohr, consequently, in the preparation of fluids containing chlorine, first of all adds to them a few drops of a solution of neutral chromate of potash, and then conducts the analysis in the ordinary way. The exact moment of the completion of the reaction is beautifully and distinctly shown, through this modification of the process; for as soon as the whole of the chlorine is thrown down by the solution of silver, the next drop of it which is added produces a beautiful red precipitate of chromate of silver. This plan, however, requires that the fluids operated upon shall be neutral, or at most only very slightly alkaline; but under no conditions must any free acid be present, on account of the ready solubility of the chromate of silver.

This method, however excellent in the case of fluids containing merely chlorides, may mislead when used in the analysis of urine, on account of its requiring a neutral reaction of the urine. Several comparative experiments, instituted first by Liebig's method, then by Mohr's, and finally by the process of weighing, invariably afforded, when performed by volumetrical analysis with the solution of silver after addition of chromate of potash, too high a result. The cause of this is easily explained. When the analysis has been accurately concluded according to Mohr's method, it will be found, that if (in order to decompose the chromate of silver which is formed) a solution of chloride of sodium be added in drops until the colour of the urine has become a clear yellow, the precipitate which is formed does not consist of pure chloride of silver. If this precipitate be filtered under exclusion of light, and after washing be treated with cold dilute nitric acid, it will impart a colour to the acid; and an appreciable quantity of silver will be shown by means of hydrochloric acid, in the filtrate.

There is no doubt that, in a neutral fluid, oxide of silver is precipitated by the colouring and extractive matters, as well as by the uric acid; and hence, necessarily results an incorrectness in the method referred to. The phosphoric acid does not interfere with the results, because chromate of silver forms before phosphate (Compare Section xi. 5). (Analytical Examples.)

The colouring and extractive matters, &c., modify the results even in an acid solution. I therefore prefer, according to Mohr's proposal, to destroy these matters by evaporation of the urine, with addition of a little pure saltpetre, and subjecting the residue to a gentle red-heat.

B. *Preparation of the solutions.*—1. *Standard solution of nitrate of silver.*—This solution must contain 18·463 grammes of silver in a litre, so that 1 C. C. of it corresponds with 10 milligrammes of chloride of sodium, or with 6·065 milligrammes of chlorine. For this purpose 18·463 grammes of chemically pure nitrate of silver are dissolved in nitric acid, the solution evaporated to dryness in a water-bath, and heated until all the free nitric acid is driven off; the residue is then treated with distilled water, and the solution thus obtained diluted up to a litre. If chemically pure fused nitrate of silver is employed, all that is required is to weigh and dissolve 29·063 grammes of it in water, and dilute it up to a litre.

2. A cold saturated solution of neutral chromate of potash.

C. *Process.*—From 1 to 2 grammes of nitrate of potash free from chlorides, are added to from 5 to 10 C. C. of urine, in a small platinum capsule, and evaporated to dryness in a water-bath. The residue is then gently heated over a naked flame, the heat being gradually increased until the carbon is completely oxidised, and the residue converted into a fused white saline mass. In this way the operation is safely conducted, and the deflagration moderated. The white mass is then dissolved in a little water, the solution poured into a beaker-glass, and the platinum capsule carefully washed with a spirt-bottle. To this alkaline fluid very dilute pure nitric acid is added drop by drop until it has become slightly acid. The acid reaction is then again removed by the addition of a little precipitated carbonate of lime. The excess of carbonate of lime is not removed by filtration, for it in no way interferes with the final results of the volumetrical analysis.

From 4 to 5 drops of the chromate of potash-solution are then added to the mixture, and the neutral solution of silver dropped into it, under constant stirring, until a distinctly reddish permanent shade is produced. This reaction is very beautiful. The fluid, which is at first of a light canary-yellow colour, exhibits at those points where the silver-solution falls reddish spots, which disappear when the fluid is shaken, so long as any chloride of sodium is present in it. Whenever the whole of the chloride of sodium is decomposed by the solution of silver, the next drop of the solution which is added produces a permanent red-colour of chromate of silver, and indicates the conclusion of the operation.

Each cubic-centimetre of the silver-solution, which has been used up to the point when the permanent red-colour appears, indicates the presence of 10 milligrammes of chloride of sodium, or 6·065 milligrammes of chlorine. Thus, for example, if in operating upon 5 C. C. of urine we have employed 5 C. C. of the silver-solution, the 5 C. C. of urine will contain 50 milligrammes of chloride of sodium; and 1000 C. C. of it 10·0 grammes, *i.e.*, 6·065 grammes of chlorine.

In most cases Liebig's method, above described, which is by far the simplest, answers very well. In many abnormal states of the urine, however, the final reaction in this process is not well marked; in such cases, therefore, we should use the second process described.

SECTION LIX.

APPENDIX.

Liebig's Method for Determination of the Mercury.

A. *Theory.*—The principle upon which this volumetrical process is founded has been already explained under the head of Phosphate of Soda (Section XIII. B. 5). We there found, that a precipitate of phosphate of mercury, provided it is not in a crystalline condition, readily re-dissolves on the addition of chloride of sodium—corrosive sublimate, which does not precipitate phosphate of soda, being formed. One equivalent of phosphate of mercury requires one equivalent of chloride of sodium for its solution; consequently, if we know the quantity of chloride of sodium in the solution which has been used, we can therefrom readily calculate the amount of oxide of mercury present.

We require two solutions in carrying out this process.

B. *Preparation of the solutions.*—1. *Standard Solution of Chloride of Sodium.*—The solution of chloride of sodium required for the volumetrical determination of the oxide of mercury, must contain 10·852 grammes of chloride of sodium in a litre. We can, therefore, either weigh out this quantity of pure fused chloride of sodium, dissolve it in water, and then dilute the fluid up to a litre, or, more simply, we can dilute 20 C. C. of the before-mentioned (Section LVIII., B. 1) cold saturated solution of chloride of sodium (containing 6·368 grammes), up to 586·8 C. C. In either case we obtain a standard solution, which contains 0·010852 gramme of chloride of sodium in every cubic centimetre corresponding with 0·020 gramme of oxide of mercury. Thus, every cubic centimetre used in the analysis indicates 20 milligrammes of oxide of mercury.

2. *A cold saturated Solution of Phosphate of Soda.*—This solution is prepared by pouring cold water over pure officinal phosphate of soda, and allowing it to stand (shaking at intervals) during twenty-four hours.

C. *Process.*—It is necessary in this process, that the solution of mercury should not be too concentrated, partly on account of the exactitude of the calculation required in measuring, and partly because the completion of the reaction is more distinctly marked in a dilute than in a concentrated fluid. The solution of mercury [illegible] [illegible] [illegible] the mixture assumes. On the addition of the [illegible] [illegible] [illegible] oxide of mercury, [illegible] does not contain any [illegible] urea having been precipitated in [illegible] The precipitate contains [illegible] equivalent of urea. The [illegible] carbonate of soda, [illegible] solution of mercury, containing [illegible] parts of the oxide, has been added to every [illegible] parts of urea in the solution of urea, that is, four equivalents of the mercury to one equivalent of urea.

When [illegible] of mercury is added to the urea-solution in a quantity insufficient for precipitation, the mixture, on the addition of the carbonate of soda, remains white; but if it be allowed to stand a few hours the precipitate alters its character, and becomes a crystalline form; and when this happens, the supernatant fluid yields a yellow precipitate with alkalies. The compound, which contains 4 atoms of oxide of mercury, if allowed to stand for some time in the acid solution, is reduced to a compound containing less of the oxide; or in other words, a part of the oxide of mercury again passes into a state of solution.

In order, therefore, to hit the point at which the whole of the urea is precipitated, i.e., when the exact quantity of mercury-solution necessary for the production of the compound containing four atoms of oxide of mercury has been added, neutralisation with the carbonate of soda is necessary. We may be sure, for example, that free urea is still present in the fluid, so long as a drop of the mixture, mixed in a watch-glass with a drop of solution of carbonate of soda, remains white. The exact point of addition is reached when a yellow colour is formed on the surface of the two drops mingled together; or, to speak more correctly, the exact point is reached and just overstepped. For the production of this completion of the test, however, only a very small excess of the oxide of mercury is required.

If we know the quantity of oxide in our mercury-solution, and have also ascertained the volume of the solution, which is required for the complete precipitation of a solution of urea of unknown quantity—*i.e.*, which must be added until the yellow colour appears on neutralising a drop of the mixture with carbonate of soda—we can calculate the quantity of urea in the solution. Or, conversely, By combining these two methods we obtain very accurate results. The following is, therefore, the best mode of proceeding:—

(Method 1.) 10 C. C. of the mercury solution are measured off, and 5 C. C. of the solution of phosphate of soda added to it. To this mixture (and without waiting until the precipitate begins to crystallise) the solution of chloride of sodium is slowly added; and we will assume that for the purpose required 12·5 C. C. of it are used.

(Method 2.) 12·5 C. C. of the same solution of chloride of sodium are accurately measured off, 4 C. C. of phosphate of soda added to it, and the same solution of mercury dropped into the mixture, until a permanent precipitate appears.

If in this process we have used, for example, 10·25 C. C. of the mercury solution, we obtain by the following calculation the exact amount required.

There were used in—

(Meth. 1.) To each 10· C. C. of the solution of mercury - 12·5 C. C. of the solution of chlor. of sodium.
(Meth. 2.) To each 10.25 C. C. do. 12·5 C. C. do.
20·25 C. C. of the solution of mercury and 25· C. C. of the solution of chlor. of mercury.

Each C. C. of chloride of sodium solution indicates 20 milligrammes of oxide of mercury; consequently the 25 C.C. which were employed correspond (20 × 25) with 500 milligrammes of oxide of mercury, which are contained in 20·25 C. C. of the dilute solution of mercury. But as we were forced to dilute this solution with an equal volume of water before using it as a test, 20·25 C. C. of it thus diluted will correspond with 10·125 C. C. of the original solution, which contains 500 milligrammes of the oxide.

SECTION LX.

THE QUANTITATIVE DETERMINATION OF UREA.

A. *Theory.*—By adding to a dilute solution of urea an equally dilute solution of nitrate of mercury, and neutralising from time to time the free acid of the mixture by carbonate of soda, we obtain a copious white flocculent precipitate, which is insoluble in water. If we continue to add alternately the solutions of mercury and of carbonate of soda, so long as this precipitate is formed, a point is at to exactly one litre. If during this process any basic salt is separated, it is allowed to subside. The clear fluid is then decanted off, and the precipitate re-dissolved by one or two drops of nitric acid. The correctness of the solution thus obtained must now be tested in the manner already described.

b. Preparation from Oxide of Mercury.—Pure oxide of mercury best serves for the preparation of the mercury-solution; it may be readily obtained by heating in a porcelain basin subnitrate of mercury, which has been several times crystallised. Commercial oxide of mercury, however, may be obtained sufficiently pure for the purpose; so high a degree of purity of the mercury not being required for the determination of the urea, as is requisite for the determination of the chlorine. An oxide of mercury which leaves no visible residue when heated on platina foil, is fitted for the purpose. Of this oxide 77·2 grammes, dried at 100° C. (212° F.), are taken by weight, dissolved under a gentle heat with the smallest possible quantity of nitric acid in a porcelain basin, evaporated to a syrup, and then diluted up to a litre. Should any basic salt separate, a few drops of nitric acid are dropped into it and the precipitate re-dissolves.

[illegible] *from subnitrate of Mercury.*—If the operator possesses no chemically pure mercury, he must make a crystalline [illegible] of mercury, in the manner described under [illegible] Section LVIII. B. 3, *a*,) and convert [illegible] acid.

The quantity [illegible] mercury contained in this solution is necessary [illegible] therefore be determined. For this purpose [illegible] described Section LIX.) may be [illegible] 10 C. C. of the con[illegible] with [illegible] ten times their volume of [illegible] and then to ascertain, [illegible] C. C. of this diluted [illegible] and the standard solution [illegible]

[illegible] solution of chloride of [illegible] diluted solution, the [illegible]

[illegible] solution—corresponding [illegible] mercury—are [illegible] solution of mercury, there are employed 5 × 18·5 = 92·5 C. C. of chloride of sodium-solution.

If, then, 10 C. C. of the concentrated mercury-solution require 92·5 C. C. of the solution of chloride of sodium, exactly 4·16 C. C. of it will be required for 38·6 C. C. of solution of chloride of sodium. Consequently, in 416 C. C are contained 77·2 grammes of oxide of mercury, which is exactly the quantity that one litre should contain. We have, therefore, only to dilute 416 C. C. of the concentrated solution up to one litre, in order to obtain a solution, of which 1 C. C. will indicate exactly 10 milligrammes of urea.

It is better, however, not to add the whole of the calculated quantity of water at once, but, first of all, to test the mixture with the urea-solution (1.), and then complete the operation. This is done in the following way:—

d. Gradation of the prepared Solution of Mercury.—Exactly 10 C. C of the urea-solution (1) are measured off with the pipette, and introduced into a small beaker-glass; the approximatively diluted mercury-solution is then added to it, guttatim, until a few drops of the mixture, neutralised on a watch-glass with carbonate of soda, yield a distinctly yellow colour.

If, up to this point, 19·25 C. C., for example, of the mercury-solution have been used, we add to each 192·5 C. C. of the same, 7·5 C. C. of water, and thus obtain 200 C. C. of a solution, 20 C. C. of which will precipitate the urea from exactly 10 C. C. of the urea-solution. The correctness of the result must be proved by a second trial; and if the yellow colour becomes distinct after the use of 20 C. C., the solution may be used for the determination of the quantity of urea in the urine.

3. *Solution of baryta.*—This solution is similar to that which is used in the determination of chloride of sodium. We obtain it by mixing one volume of solution of nitrate of baryta with two volumes of caustic baryta-solution, both prepared by cold saturation.

c. *Process.*—In order by this process to determine the quantity of urea in the urine, the phosphoric acid, as in the case of chloride of sodium, must be separated. For this purpose, 40 C. C. of the urine are measured off with the pipette, and mixed with 20 C. C. of baryta-solution; the precipitate which is formed is then separated by filtration, the filter not being previously moistened. 15 C. C. of the filtrate, corresponding with exactly 10 C. C. of urine, are measured out for each analysis. In most cases one volume of baryta-solution suffices for the separation of all the phosphoric and sulphuric acids contained in two volumes of urine, a little of the baryta being still left in the solution.

If the urine contains alkaline carbonates—which may be in some cases represented by carbonate of ammonia, derived from decomposed urea, or if it has a very acid reaction, one volume of baryta-solution will not suffice for two volumes of urine; more of it, therefore, must be employed. When three volumes of baryta-solution are mixed with four volumes of urine, we take 17·5 C.C. of the filtrate, corresponding with 10 C.C. of urine; with equal volumes of baryta-solution and urine we take for the test 20 C.C., and so on.

To this quantity of urine thus measured out, and without any previous neutralising (which is required in the determination of the quantity of chloride of sodium) the graduated mercury-solution is added with Mohr's pipette, the mixture being constantly stirred; when no further precipitation or turbidity is observed to follow the addition of the solution, the test may be applied. For this purpose, a few drops of the mixture are placed by means of a glass-rod upon a watch-glass, and some drops of carbonate of soda-solution allowed to run down upon them from the edge of the glass, to effect which Mohr's [illegible] pipette may be advantageously employed. If the mixture retains for some seconds its white colour, it still contains free urea. More of the mercury-solution must, therefore, be dropped into it, after which it must be tested again; and this is to be repeated until, on a renewal of the test, a distinct yellow colour appears when the carbonate of soda-solution is added in the watch-glass.

The shade of yellow must be similar to that which was produced when the graduated solution of mercury was originally prepared. If different shades of yellow are admitted in the testing, error must result. A little practice will enable the observer to fix upon the true shade of yellow.

The amount of the urea is calculated from the quantity of mercury-solution which has been used. Corrections, however, are necessary, under certain circumstances, and of these we may notice the following:—

β. *[illegible] and Corrections required under certain circumstances.*—1. *Urine containing more than 2 p. c. of urea.* The mercury-solution is graduated for a solution of urea, which contains 2 p. c. of urea; we therefore require 30 C.C. of mercury-solution for the complete precipitation of the urea in every 15 C.C. of the urea-solution, as well as for attaining the final reaction with carbonate of soda. The mixture thus makes up 45 C.C. and contains $30 \times 5{\cdot}2 = 156$ milligrammes of free oxide of mercury; consequently, every cubic centimetre contains 3·47 milligrammes. If the 15 C. C. of urea-solution contain 4 per cent. of urea; and if to 15 C.C. of it we add 60 C.C. of mercury-solution, we have a mixture consisting of 75 C.C., in which are contained $60 \times 5{\cdot}2 = 312$ milligrammes of free oxide of mercury, and, therefore, 4·16 milligrammes in each cubic centimetre, and consequently, 0·69 milligramme more of the oxide than is required for the final reaction with carbonate of soda.

It is therefore clear, that in the analysis of urine, an error will arise, whenever the quantity of urea exceeds 2 p. c.—less than the true quantity of urea being in such case given. If the urine, as in the above case, contains 4 p. c. of urea, we should not require 60, but only 59·37 C. C. of the mercury-solution.

This error is avoided if, in experimenting on 15 C. C. of urine, and before resorting to the carbonate of soda-test, we add to the mixture, for the number of cubic centimetres of mercury-solution, more than 30, which are required for the precipitation, half the number of cubic centimetres of water. If, for example, we use 50 C. C. of mercury-solution to 15 C.C. of urine, that is, 20 C. C. more than 30, we must add 10 C. C. of water, before resorting to the carbonate of soda test.

2. *Urine containing less than 2 p. c. of Urea.*—For exactly the same reasons, as those above given, we must, when the urine contains only 1 per cent. of urea, add to each 15 C. C. of the urine, not 15 C. C. of the mercury-solution, but 15·3 C. C. before we reach the final test point. In consequence of this source of error the quantity of urea obtained is too great. We must, therefore, in operating upon more diluted urine, for every 5 C. C. of the mercury-solution, less than 30 C. C. which is used, abstract 0·1 C. C. from the total sum of the mercury-solution employed. Thus, for instance, if we have employed for 15 C.C. of urine 25 C. C. of mercury-solution, that is 5 less than 30 C. C., we must subtract 0·1 C. C. for these 5, and therefore reckon only 4·29 C. C. of mercury-solution, &c.

3. *Urine containing Chloride of Sodium.*—When the quantity of chloride of sodium in the urine reaches to from 1 to 1½ per cent.

[illegible] [illegible] with the [illegible] of the urea by means of the [illegible] [illegible]. [illegible] of the urea-solution [illegible] of the mercury-solution [illegible] in the [illegible] a [illegible] with carbonate of soda. [illegible] of the urea-solution [illegible] milligrammes [illegible]. In such case, [illegible] and [illegible] 1½ to [illegible] of the mercury-solution. The [illegible] of urea [illegible] 20 milligrammes too much. Exactly the same thing [illegible] in urine, which contains from 1 to 1½ per cent. of chloride of sodium. This phenomenon depends upon the formation of corrosive sublimate.

[illegible] of mercury and chloride of sodium decompose each other, forming corrosive sublimate and nitrate of soda. Corrosive sublimate, however, does not precipitate a weak acid solution of urea, but remains in solution. The same thing happens in the determination of urea in the urine; the excess of oxide of mercury, which should form the yellow colour on the addition of carbonate of soda, exists, under the circumstances supposed, not in the form of a nitrate, but of corrosive sublimate, together with free nitric acid. If, under such conditions, carbonate of soda is added to the mixture, bicarbonate of soda, which does not throw down the sublimate, is formed by the action of the free nitric acid. Consequently, the [illegible] does not take place, and we must add more nitrate of mercury in order to produce it. If the mixture contains a larger quantity of chloride of sodium than 1 to 1½ per cent., the quantity of sublimate formed will also be increased; so that, on the addition of carbonate of soda, the carbonic acid which is set free not being able to prevent the precipitation of the whole of the oxide of mercury, a brownish-yellow precipitate appears. This, according to Liebig, is the reason why the indication of the complete precipitation of the urea is not altered with [illegible] the presence of a certain quantity of chloride of sodium [illegible] per cent., and why the limit of the reaction is not [illegible] when the quantity of chloride of sodium is still more increased.

If, then, the urine contains from 1 to 1½ per cent. of chloride of sodium, we must, in order to ascertain the exact number of milligrammes of urea in 10 C.C. of urine, subtract 2 C.C. from the number of cubic centimetres of the mercury-solution which have been used, and only calculate the quantity of urea from the remainder. The results thus obtained will be found correct and comparative.

If, however, we wish to learn the absolute quantity of urea in the urine, we must, first of all, separate the chlorine. For this purpose we may use a silver-solution of known strength, 1 C. C. of which exactly corresponds with 10 milligrammes of chloride of sodium, just as the mercury-solution in the calculation of the chloride of sodium.

Such a silver-solution may be obtained by dissolving 11·601 grammes of fused nitrate of silver in water, and then diluting the mixture up to 400 C. C. 1 C. C. of this corresponds with 10 milligrammes of chloride of sodium. The execution of the process is then as follows:—

In 15 C. C. of urine, which has been precipitated by the baryta-solution, and which, therefore, correspond with 10 C. C. of the original urine, we ascertain the quantity of chloride of sodium by means of the mercury-solution (See Section LVIII.). If, for example, we have used 17·5 C. C. in producing a permanent cloudiness, the quantity used indicates 175 milligrammes of chloride of sodium, which will therefore be completely precipitated by the corresponding silver-solution. We now, by means of the pipette, measure off 30 C. C. of the same urine-mixture, and by the addition of a drop of nitric acid, give it a weak, but still a distinctly acid reaction; and then mix with this volume 2 × 17·5 C. C. = 35 C. C. of the silver-solution. The total volume of the mixture will therefore equal 65 C. C. The chloride of silver which is formed is separated by filtration, and one-half of the mixed fluid—that is 32·5 C. C.—is then subtracted from the filtrate, which contains 10 C. C. of urine.

The urea in this quantity may now be determined in the usual way with the standard mercury-solution, due regard being paid to the dilution consequent on the addition of the silver-solution (D. 2).

4. *Urine containing Albumen.*—If the urine contains albumen, neither the urea nor the chloride of sodium can be determined directly in the manner above described, until the albumen has been previously separated. The following modification of the ordinary process is, therefore, required.

From 100 to 200 C. C. of the urine are heated in a closed glass in a water-bath, until the albumen in it is completely coagulated, and has separated in thick flocculi so as to leave the urine clear. If the thick flocculi of albumen should not form on account of a [illegible] the urine, acetic acid is carefully dropped into [illegible] to produce them. Half-an-hour's exposure [illegible] The fluid, with the albuminous coagulum, is well- [illegible] filtered when cold, and the clear filtrate employed [illegible] the chlorine, urea, phosphoric acid, &c.

[illegible] *Carbonate of Ammonia.*—As the carbonate [illegible] is met with in the urine depends upon the [illegible] it may under certain circumstances be inte- [illegible] the quantity of urea which corresponds with [illegible] of ammonia. Liebig found, that even fetid am- [illegible] provided the decomposition had not advanced [illegible] the same results as fresh urine. If nitrate [illegible] urine of this kind a precipitate, contain- [illegible] of oxide of mercury for 1 equivalent of am- [illegible] the same quantity of oxide of mercury is [illegible] as for undecomposed urea, because urea, [illegible] gives off 2 equivalents of ammonia (1 equiva- [illegible] 4 equivalents of oxide of mercury). Experiment, how- [illegible] that this relation is not invariable, and that in fact a greater [illegible] the mercury-solution is frequently employed. If, there- [illegible] results are required, the quantity of ammonia and urea [illegible] determined, and the first calculated as urea. [illegible] may be employed :—

[illegible] of urine is precipitated with baryta-solu- [illegible] of the solution, corresponding with 10 C.C. of urine, heated in a water-bath until ammonia is driven off. The urea is then calculated in the ordinary way. In a second portion of the urine, which has not been treated with baryta-solution, the volume of ammonia is volumetrically determined by standard sulphuric acid, each cubic centimetre of which corresponds with 11·32 milligrammes of ammonia, or 20 milligrammes of urea. (500 C.C. of such an acid, therefore, contains 16·333 HO, SO_3.)

A certain quantity of the urine, which has been treated with baryta-solution, is subjected to distillation, and the ammonia which passes over received in a known volume of standard sulphuric acid. By means of a soda-solution, which corresponds with the sulphuric acid, the remainder of the unsaturated acid is ascertained; and the number of saturated cubic centimetres of acid thus obtained, are calculated as for the urea; 1 C.C. of sulphuric acid corresponding [illegible] milligrammes of urea. The results obtained by this second method are more correct than by the first. (For the preparation of the sulphuric acid and soda-solutions, see Section LXX.)

From a series of comparative experiments Kletzinsky found, that small quantities of other nitrogenous bodies are precipitated from the urine with the urea by nitrate of mercury; consequently the quantity of urea as above given is too high. These unknown substances may be separated by precipitation with sugar of lead, and their disturbing influence thus removed. They amount on an average to about 2 per cent.; for Kletzinsky obtained, as the mean of many urea-calculations, which he made (on one occasion after the ordinary method, and at another by the above process of precipitation with sugar of lead), 0·593 gramme, instead of 0·580 gramme of urea in 10 C. C. of urine. The error is so trifling, that in ordinary urine-analyses previous precipitation of the urine with sugar of lead, acidulated with acetic acid, may be omitted as superfluous. These substances also yield ammonia when boiled with sulphuric acid, and thus interfere with Ragsky and Reintz's method of urea-calculation (*Prager Vierteljahresschrift*, 1855, 11, page 83).

Lastly, I must remark, that allantoine is precipitated by nitrate of mercury just as is urea. The method above described will therefore be incorrect, when the urine contains allantoine. Allantoine, however, has never yet been found either in the normal or abnormal urine of man, even when uric acid has been ingested. Professor Städeler, it is true, states that he has found allantoine in the urine of dogs suffering from impeded respiration. More marked, although trifling, is the error occasioned by the constant presence of creatinine in the urine; for, as I have found, this compound is also precipitated by nitrate of mercury. The daily quantity of creatinine averages, under normal circumstances, 0·8 to 1 gramme.

I omit the two admirable methods of Bunsen and Ragsky for the quantitative determination of the urea, for their processes are both difficult and tedious, and therefore not adapted for the purposes of the practical physician. I have already briefly pointed out the principle on which they are founded (See Sect. II., D. 2); and as regards the processes, I refer the reader to *Gorup-Besanez zoochemische Analyse*, pp. 269-271. *Annalen d. Chem. u. Pharm.* Bd. 56, pp. 29-34; Bd. 65, pp. 357-387.

The calculation proposed by Millon (Sect. II. D. 3), as regards the shortness of the process, stands next to Liebig's, but it is rendered unnecessary by Liebig's process.

SECTION LXI.

DETERMINATION OF THE PHOSPHORIC ACID.

1. *With Salts of Uranic Oxide.*

a. Theory.—A precipitate of phosphate of uranic oxide is immediately formed, when a hot solution of a phosphatic salt which is soluble in water or acetic acid, is treated with a solution of acetate or nitrate of uranic oxide in presence of free acetic acid. If the solution contains much ammoniacal salt, the precipitate will likewise contain ammonia. The phosphate of uranic oxide thus thrown down contains 80·09 parts of uranic oxide to 19·91 parts of phosphoric acid, and appears as a whitish-yellow, passing even into a greenish precipitate: it is completely insoluble in water and acetic acid, but soluble in mineral acids. The exact point of the completion of the reaction cannot be ascertained in the fluid, on account of the slimy character of the precipitate, and of the slowness of its deposition: consequently, in order to determine, whether or not the whole of the phosphoric acid is precipitated, a small excess of uranic oxide must be added,—the presence of this salt being readily shown by the highly sensitive reaction of the salts of uranic oxide with ferrocyanide of potassium.

b. The salts of uranic oxide yield, with ferrocyanide of potassium, a reddish-brown precipitate, through which the smallest trace of uranic oxide is rendered visible, a corresponding degree of reddish-brown colouring being thereby imparted to the fluid.

Phosphate of uranic oxide once thrown down, is not decomposed by ferrocyanide of potassium like freshly-precipitated per-phosphate of iron; consequently, in testing for an excess of uranic oxide, a drop of the mixture can be added to the ferrocyanide of potassium-solution. The mixture remains uncoloured, if no free uranic oxide is present; but if it contains the slightest excess of uranic oxide, its presence is at once distinctly shown by a corresponding degree of red-coloration of the fluid. Phosphate of uranic oxide, moreover, is a very constant compound, and does not, like the phosphate of iron, pass into basic combinations, which contain an excess of the salt of uranic oxide. Hence, when the exact point of [illegible] has been distinctly obtained, it may be once again demonstrated (after the fluid has stood even for a day); whilst in volumetrical analysis with per-chloride of iron, the point of reaction cannot be shown again, even after a few minutes, and consequently this process is exceedingly untrustworthy and erroneous.

The reaction of ferrocyanide of potassium with uranic oxide is not, however, so sensitive in solutions which contain acetate of soda, as in pure aqueous solutions. This is readily shown by taking 50 C. C. of water and 50 C. C. of a solution of acetate of soda containing 0·5 gramme of the acetate, and 1 gramme of free acetic acid, treating them with 0·2 C. C. of the same solution of uranic oxide, and then testing with ferrocyanide of potassium. The distilled water immediately assumes a very distinct brown colour, whilst the solution of acetate of soda gives a much feebler reaction, the fluid becoming only gradually of a deeper colour. No reaction at all takes place on the first application of the test, if the solution contains a larger quantity of acetate of soda; but after some length of time and on the addition of a further quantity of the ferrocyanide of potassium, the reaction appears.

This fact is of great importance. According as, in the volumetrical analysis of phosphoric acids by salts of uranic oxide, sometimes more and sometimes less of the acetate of soda is added, for example, to every 50 C. C. of urine, will more or less of the uranic oxide-solution be required, for an equal quantity of phosphoric acid, in order to attain the final reaction-point with ferrocyanide of potassium. Hence may arise an error, which is, however, readily avoided, by always taking a given quantity of fluid and treating it, before the volumetrical analysis, with an equal quantity of acetate of soda.

B. *Preparation of the solutions.—a. Standard Phosphoric Acid-Solution.*—This solution should be so constituted as to resemble the urine as nearly as possible, as regards its phosphoric acid contents; 50 C. C. of it should contain 0·1 gramme of phosphoric acid. It may be readily prepared from chemically pure, well-crystallised, phosphate of soda, which has not undergone efflorescence. The pure crystals are rubbed down as fine as possible, dried between folds of bibulous paper, 10·085 grammes weighed and dissolved in a litre of water. 50 C. C. of this solution contain exactly 0·1 gramme of phosphoric acid.

b. Acetate of Soda-Solution.—I have satisfied myself, by numerous experiments, that 0·5 gramme of acetate of soda is, under all circumstances, sufficient for 50 C. C. of urine. Consequently, 100 grammes of acetate of soda are dissolved in 900 C. C. of water, and the solution brought up to a litre by the addition of 100 C. C. of concentrated acetic acid. In the volumetrical process 50 C. C. of urine are treated with 5 C. C. of this acid solution of acetate of soda.

c. *Solution of Uranic Oxide.*—Pure commercial uranic oxide, or yellow carbonate of soda-uranic oxide, is dissolved in pure acetic acid, free from all empyreumatic matters, the solution diluted, and its strength tested with the standard phosphate of soda-solution (*a*). I have found it convenient so to employ the uranic oxide-solution, as that 1 C. C. of it should precipitate, and indicate the presence of only 0·005 gramme of phosphoric acid. 50 C. C. of the phosphoric acid-solution (*a*) = 0·1 gramme of phosphoric acid, would consequently require exactly 20 C. C. of the uranic oxide-solution: this solution, therefore, must, in the first place, contain 0·4028 gramme of uranic oxide for the precipitation of the phosphoric acid, and, secondly, a slight excess of uranic oxide for the indication of the completion of the reaction.

Hence, then, 50 C. C. of phosphoric acid solution (*a*) (0·1 gramme phosphoric acid) are measured off into a beaker-glass, 5 C. C. of the acid solution of acetate of soda (*b*) added, and the mixture heated in a water-bath to from 90° to 100° C. (194° to 212° Fahr.). The uranic oxide solution is next added, and the mixture tested after the addition of each ½ C. C. to see whether or not the reaction-point has been reached. For this purpose, 1 or 2 drops of the mixture are allowed to spread over a white porcelain surface, and a little drop of a weak yellowish solution of ferrocyanide of potassium introduced, by means of a small glass rod, into the centre of the drop. If there should be a trace merely of excess of the uranic oxide present, a reddish-brown circlet will be formed at the point of contact of the drops. This inner circlet is rendered very distinct by the surrounding lightish yellow-coloured fluid.

I prefer this mode of testing to every other. When, after repeated trials and additions of the uranic oxide-solution, we obtain some slight signs of the completion of the reaction, we again apply the heat of the water-bath for a few minutes, and then once more repeat the test. If the reaction is now well marked, the test is

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of the solution of phosphoric acid require 20 C. C. of the uranic oxide-solution, which again must indicate and precipitate 5 milligrammes of phosphoric acid. If, for example, we employ 18·0 C. C. of the uranic oxide-solution to 50 C. C. of phosphoric acid-solution, we must add to each 180 C. C. of the same 20 C. C. of water. For this purpose we measure off 1 litre of the uranic oxide-solution, and add to it the quantity of water required. In the case supposed, 111·2 C. C. of water must be added to 1000 C. C. of uranic oxide-solution to produce the required degree of strength. It is best, however, not to add the whole of the water at once, but, before doing so, once more to test a portion with the phosphoric acid-solution, and then to complete the uranic oxide-solution.

Thus, if we have a second time used 19·8 C. C. of uranic oxide-solution to 50 C. C. of phosphoric acid-solution (0·1 gramme phosphoric acid), we add to each 198 C. C. of the same 2 C. C. of water, and make a new and final test with the phosphate of soda-solution.

The uranic oxide-solution, each cubic centimetre of which precipitates 5 milligrammes of phosphoric acid, and which also contains a small excess of uranic oxide for the final reaction, must contain 20·3 grammes of pure uranic oxide in a litre. (Equivalent of uranium = 59·4.)

c. *Process.—a. Determimation of the entire quantity of the phosphoric acid in the urine.*

1. 5 C.C. of the acetate of soda-solution are added to 50 C.C. of filtered urine in a beaker-glass, the mixture heated in a water-bath, and uranic oxide-solution dropped into it from a Mohr's pipette, divided into tenths of centimetres. As soon as the precipitation ceases, which may be pretty clearly observed, if the uranic oxide-solution is allowed to trickle down the side of the glass without shaking the mixture, we proceed to the testing. One or two drops of the mixture are placed upon a white porcelain surface, and a drop of a slightly yellow-coloured solution of ferrocyanide of potassium introduced by means of a thin glass rod into the middle of the spread-out drop of the mixture. If a small excess of uranic oxide is present, a little island of a reddish-brown shade, surrounded by a colourless or slightly yellow-coloured fluid, will be distinctly observed at the points where the ferrocyanide of potassium-solution comes in contact with the mixture. When a weak final reaction appears, the mixture is again heated for a minute or two in a water-bath, and again tested; if the reaction is still distinct, *if the colour*

[illegible] *corresponds with the shade of colour which appeared when* [illegible] *oxide-solution was originally prepared*, the test is completed.

In other cases we continue the addition of the uranic oxide-solution until the final reaction becomes distinct and permanent. [illegible] the exact point of final reaction has been exceeded by [illegible] much of the uranic oxide-solution, and if a deep [illegible] immediately appears on the application of the test of [illegible] of potassium, we add to the mixture (according to circumstances) [illegible] 10 to 20 C.C. of urine, and then carefully add [illegible] oxide-solution, until the proper shade of colour is obtained.

[illegible] remarked, the action of ferrocyanide of potassium on [illegible] is delayed by the presence of acetate of soda; the single [illegible] darker and darker, which might be a source [illegible] observer. Under all circumstances it is best to regard [illegible] of the process, the first appearance of a slight [illegible] in the middle, which, after two or three minutes [illegible] in the water-bath, can be again made to produce the [illegible] though the brown colour should markedly increase [illegible] fifteen minutes.

[illegible] both of whom, like myself, propose the [illegible] conduct the process in the cold. I, [illegible] because the complete separation of [illegible] takes place much more rapidly in [illegible] C.C. of uranic oxide-solution have [illegible] C.C. of urine, the first appearance [illegible] permanent reaction, the 50 C. C. will contain [illegible] which may be readily calculated [illegible]

[illegible] distinctly marked, if the whole of [illegible] precipitated from the urine by [illegible] acid estimated in the manner [illegible] For this purpose, 50 [illegible] magnesia-mixture (a clear [illegible] and ammonia), and the [illegible] The ammonio-phosphate [illegible] washed with ammoniacal [illegible] 3 parts of water, and the precipi- [illegible] through the broken filter into a beaker-glass.

After heating in a water-bath, acetic acid is added in drops until solution is accomplished; the mixture is then diluted with water up to 50 C.C., 5 C. C. of acetate of soda are added, and finally graduated with the uranic oxide-solution, as above described.

This tedious process is rarely required, for the results are usually very satisfactory in direct volumetrical determination of the urine. By this second process we employ, in operating upon the same urine, about $\frac{1}{10}$ C. C. of uranic oxide-solution less, and this equals for the twenty-four hours' urine of 1500 C. C., about 0·15 to 0·2 gramme of phosphoric acid.

b. Determination of the phosphoric acid combined with the earths.

To determine the quantity of phosphoric acid combined with the earths, 100 to 200 C. C. of the filtered urine, according to its degree of concentration, are treated with ammonia until alkaline reaction is produced, and allowed to stand twelve hours. The earthy phosphates separated during that time are collected on a filter, and washed with ammoniacal water,—one part of ammonia to three parts of water. The precipitate is then washed through the broken filter into a beaker-glass, heated and dissolved in the smallest possible quantity of acetic acid; and the mixture, after 5 C. C. of the acetate of soda-solution have been added, and the whole volume increased to 50 C. C., graduated with the uranic oxide-solution after the manner described (*a*).

Example.—50 C. C. require for the determination of the whole of the phosphoric acid of the urine, 18·4 C. C. of uranic oxide-solution = 0·092 gramme of phosphoric acid. Thus, in 1000 C. C. is contained 1·840 gramme. For the determination of the earths, combined with the phosphoric acid, 6 C. C. of uranic oxide-solution = 0·03 gramme of phosphoric acid, are employed for each 100 C. C. of urine. Consequently, 0·300 gramme in 1000 C. C.

Thus the urine contains:—

a. The whole of the phosphoric acid = 1·840 gramme.
b. Phosphoric acid combined with earths = 0·300 gramme.
c. Phosphoric acid combined with alkalies = 1·540 gramme.

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Thus the urine contains:—

a. The whole of the phosphoric acid = 1·840 gramme.
b. Phosphoric acid combined with earths = 0·300 gramme.
c. Phosphoric acid combined with alkalies = 1·540 gramme.

b. Solution of acetate of soda.—After making numerous experiments, I found that 1 gramme of acetate of soda must be added for every 10 or 15 C. C. of the graduated iron-solution, provided it does not contain too much free hydrochloric acid. We must therefore prepare a solution of 20 grammes of crystallised acetate of soda in 200 C. C. of moderately strong acetic acid; 10 C. C. of this solution contain 1 gramme of acetate of soda.

c. *Process.—a. Determination of the whole amount of phosphates.*—50 C.C. of the urine to be tested are measured off by a pipette into a beaker-glass, and mixed with 10 C. C. of the acetate of soda solution. A piece of filtering-paper is then moistened with ferrocyanide of potassium-solution, and spread out upon a white porcelain plate. The standard iron-solution is now added to the urine by drops (the mixture being constantly shaken, and frequently tested), in order to ascertain when the process is complete, and a small excess of iron-solution has been added. The test should be applied after the addition of each half cubic centimetre. A small piece of filtering-paper, moistened with the ferrocyanide of potassium-solution, as already described, is doubled together and then pressed upon with a glass-rod, which has a drop of the mixture adherent to it. If an excess of the iron is present, a blue colour appears on the paper in the course of few seconds. The experiment is complete as soon as the well-marked blue colour can be reproduced, even after an interval of some few minutes, without the addition of any more of the iron-solution to the mixture. This point, indicating the completion of the operation, may be accurately enough hit upon by the assistance of the prescribed quantity of free acetic acid. If too small a quantity of acetic acid be present, the operation becomes very difficult, and often indeed impossible, on account of the ready decomposition of the peracetate of iron, as well as of the great tendency of perphosphate of iron to undergo basic combinations.

The number of cubic centimetres of the iron-solution, which has been used, gives us the amount of phosphoric acid contained in the 50 C. C. of urine, every cubic centimetre corresponding with 10 milligrammes of phosphoric acid. The experiment is repeated a second time to control the result; and if both these experiments agree, we may conclude that the calculation is complete.

If the urine is alkaline, and has already separated a portion of its earthy phosphates as sediment, a few drops of hydrochloric acid must be first of all added to it in order to re-dissolve the precipitate.

From 10 to 20 C. C. of the acetate of soda-solution are then added to the 50 C. C. of urine, according as much or little of the hydrochloric acid has been employed, and the operation completed as before described.

b. Determination of the phosphoric acid combined with the alkalies only.—In order to learn the quantity of phosphoric acid which is combined with the alkalies in the urine, it is necessary, in the first place, to separate the earthy phosphates. For this purpose, 50 C. C. of the urine are measured off, and rendered slightly alkaline by the addition of a few drops of ammonia. By this means the whole of the phosphoric acid, combined with the earths, is separated. After a few hours, the precipitate of phosphate of lime and of ammonio-phosphate of magnesia, is separated by filtration, and carefully washed with water containing a little ammonia. The filtrate, after being neutralised with acetic acid, is treated with 10 C. C. of acetate of soda-solution, and then graduated with the iron-solution, as already described. The number of cubic centimetres of the iron-solution employed gives the quantity of phosphoric acid combined with the alkalies; and by subtracting this quantity from the whole of the phosphates (obtained by process *a*) we obtain, as the difference, the quantity of phosphoric acid in combination with the earths.

SECTION LXIII.

DETERMINATION OF THE AMOUNT OF FREE ACID IN THE URINE.

A. *Theory.*—The acid reaction of the urine does not depend solely upon the acid phosphate of soda. Other free acids—lactic acid, for example—assist in producing it. We must, therefore, in determining the acidity endeavour to find its saturating capacity by comparison with that of some other known acid. For this purpose crystallised oxalic acid is selected; so that we have to determine, how much oxalic acid corresponds with the free acid in a given quantity of urine. This we do, by accurately neutralising a known quantity of the urine with an alkaline solution, each cubic centimetre of which corresponds with a known quantity of oxalic acid. Caustic soda-

SECTION LXII.

DETERMINATION OF THE PHOSPHORIC ACID BY MEANS OF PERCHLORIDE OF IRON.

A. *Theory.*—A solution of phosphate of soda, which contains also both acetate of soda and free acetic acid, when treated with a dilute solution of perchloride of iron, yields a voluminous whitish-yellow precipitate of phosphate of iron, containing one equivalent of oxide of iron to one equivalent of phosphoric acid. So that, if we add acetate of soda to a solution containing an unknown quantity of phosphoric acid, and then add a standard solution of perchloride of iron until the whole of the phosphoric acid is thrown down, and a trace of an excess of the iron appears in the mixture, we can reckon the quantity of phosphoric acid, by taking the amount of iron-solution employed. One equivalent of oxide of iron throws down one equivalent of phosphoric acid. In order, therefore, to ascertain that a small excess of the perchloride of iron has been added to the solution, and that the process is complete, a small piece of filtering-paper, moistened with a solution of ferrocyanide of potassium, is laid upon a white porcelain plate (or on a piece of glass placed over white paper); another piece of paper is then placed over it, and a drop of the mixture, on the end of a glass rod, pressed on the surface of this second paper. If the mixture contains an excess of the iron-solution, a blue colour will appear in the course of a few seconds.

It must, however, be observed, that the precipitate caused by chloride of iron in a fluid containing phosphoric acid, only retains the composition above given ($Fe_2\,O_3$, $P\,O_5$) so long as an excess of phosphoric acid is present. When we add the iron-solution in small excess, we shall, during the first few seconds afterwards, obtain the reaction mentioned with the ferrocyanide of potassium; in a very short time, however, the reaction disappears. A few drops of perchloride of iron will reproduce it, but after a few minutes it will disappear for a second time.

Any one can readily satisfy himself of the fact by experiment. The cause of it is this: the precipitated perphosphate of iron decomposes the perchloride of iron which has been added in excess, and by taking up more of the oxide passes into a more basic compound. We must, therefore, watch for the first distinct coloration which appears, and regard it as indicating the completion of the process, even though it disappears after a time. The greater the quantity of free acetic acid which the mixture contains, the more slowly does the colour disappear. In order, therefore, to hit the exact point of completion of the process, these facts must be carefully noted. The perchloride of iron added in excess is immediately converted into peracetate of iron by the acetate of soda which is present, and the fluid in consequence usually assumes a somewhat darker colour. This process is not nearly so delicate as that with the salts of uranic oxide.

B. *Preparation of the solutions.—a. Standard solution of perchloride of iron* is obtained by dissolving 15·556 grammes of chemically pure iron (pianoforte wire-strings) in pure hydrochloric acid, adding a little nitric acid. The mixture is then carefully evaporated to dryness in a water-bath, in order to drive off the excess of hydrochloric acid, and the residue (care being taken to prevent any loss of it) dissolved in water, and diluted up to 2000 C. C. 1 C. C. of this solution exactly corresponds with 10 milligrammes of phosphoric acid.

Instead of this solution of perchloride of iron, one of unknown strength may be used, its strength being ascertained by volumetrical analysis. For this purpose we prepare a solution of phosphate of soda, which contains in 50 C. C. exactly 0·1 gramme of phosphoric acid (see Section LXI., B. *a*), and then drop into it the chloride of iron solution, to which 10 C. C. of the acetate of soda-solution (*b*) have been previously added, by means of a pipette, until it is found that a drop of the mixture, when tested as above described, produces a distinct blue colour on paper moistened with a solution of ferrocyanide of potassium, which blue colour, after three or four minutes, may be again recalled without any further addition of the iron-solution. The quantity of the iron-solution employed in the process up to this point corresponds with 0·1 gramme of phosphoric acid.

This method is preferable in every way to the former, for the error occasioned by the excess of the iron solution, which in 50 C. C. of urine amounts to about from 1·5 to 2 C. C. of phosphoric acid solution, is already accounted for in the graduation process, and consequently disappears when the precise quantity is calculated. The degree of the blue colour should be carefully noted, in order that the same relative colour of the mixture may be always obtained. The perchloride of iron-solution employed must be absolutely free from protochloride of iron and hydrochloric acid.

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hydrochloric acid. We must th
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From 10 to 20 C. C. of the acetate of soda-solution are then added to the 50 C. C. of urine, according as much or little of the hydrochloric acid has been employed, and the operation completed as before described.

b. Determination of the phosphoric acid combined with the alkalies only.—In order to learn the quantity of phosphoric acid which is combined with the alkalies in the urine, it is necessary, in the first place, to separate the earthy phosphates. For this purpose, 50 C. C. of the urine are measured off, and rendered slightly alkaline by the addition of a few drops of ammonia. By this means the whole of the phosphoric acid, combined with the earths, is separated. After a few hours, the precipitate of phosphate of lime and of ammonio-phosphate of magnesia, is separated by filtration, and carefully washed with water containing a little ammonia. The filtrate, after being neutralised with acetic acid, is treated with 10 C. C. of acetate of soda-solution, and then graduated with the iron-solution, as already described. The number of cubic centimetres of the iron-solution employed gives the quantity of phosphoric acid combined with the alkalies; and by subtracting this quantity from the whole of the phosphates (obtained by process *a*) we obtain, as the difference, the quantity of phosphoric acid in combination with the earths.

SECTION LXIII.

DETERMINATION OF THE AMOUNT OF FREE ACID IN THE URINE.

A. *Theory.*—The acid reaction of the urine does not depend solely upon the acid phosphate of soda. Other free acids—lactic acid, for example—assist in producing it. We must, therefore, in determining the acidity endeavour to find its saturating capacity by comparison with that of some other known acid. For this purpose crystallised oxalic acid is selected; so that we have to determine, how much oxalic acid corresponds with the free acid in a given quantity of urine. This we do, by accurately neutralising a known quantity of the urine with an alkaline solution, each cubic centimetre of which corresponds with a known quantity of oxalic acid. Caustic soda-solution serves best for the purpose, as it does not, like ammonia, lose its activity by evaporation; it also enables us to ascertain with perfect accuracy the point of neutralisation.

B. *Preparation of the solutions.—a. Standard oxalic acid solution.*—This solution serves for the graduation of the caustic soda solution. It is prepared by dissolving 1 gramme of pure oxalic acid, which has not effloresced, and diluting it up to 100 C. C. Each 10 C. C. of this solution contains 100 milligrammes of oxalic acid.

b. Tincture of litmus.—1 gramme of litmus is digested for some time in 150 grammes of alcohol, and the deep-blue solution thus obtained is then fitered.

c. Caustic soda-solution is prepared in the ordinary way, by means of caustic lime, from carbonate of soda; and its activity determined with the oxalic acid-solution (*a*). Each cubic centimetre indicates 10 milligrammes of oxalic acid.

10 C. C. of the oxalic acid-solution are accurately measured off by the pipette into a small beaker-glass, and rendered of a distinctly red colour by the addition of from 6 to 10 drops of tincture of litmus (*b*). The glass is then placed upon a white-coloured ground, and the dilute soda-solution dropped into it, until the fluid has again become blue. This point may be ascertained with the nicest accuracy, the red colour passing very suddenly into blue. Thus 6 C. C., for example, of the soda-solution employed in the process will correspond with 100 milligrammes of oxalic acid; we therefore add 400 C. C. of water to 600 C. C. of the soda-solution, and thus obtain 1 litre of soda-solution, each cubic-centimetre of which exactly corresponds with 10 milligrammes of oxalic acid. We satisfy ourselves of the accuracy of the dilution by a second trial; and if, after the last drop of 10 C. C. has been added, the blue colour appears, the soda-solution may be safely employed for determining the amount of acids in the urine.

C. *Process.*—The tincture of litmus cannot be added directly to the urine, as the colour of the urine prevents the passage of the red into blue being accurately observed. Consequently, in determining the point of saturation in the urine we must employ litmus-paper, and carry out the process in the following way:—

The standard soda-solution is added by drops to 50 or 100 C. C. of urine, which have been measured off into a beaker-glass. After the addition of each half cubic centimetre a drop of the mixture is taken out on a glass-rod, and placed upon a piece of sensitive blue litmus-paper; if the spot is reddened and retains its red colour for a few seconds, we must continue the addition of the soda-solution, until, in fact, the reddening of the litmus-paper is no longer perceptible. We then place a drop of the mixture on reddened litmus-paper, and observe whether the paper becomes blue. If this is the case, we must then notice the quantity of soda-solution which has been employed, and repeat the experiment with a new quantity of urine; this time, however, not quite so many drops must be employed. In this way, and by frequent testing, the point of saturation may be accurately ascertained.

SECTION LXIV.

Determination of the Sulphuric Acid in the Urine.

A. *Theory.*—The process for determining the quantity of sulphuric acid in the urine consists in adding a standard solution of chloride of barium to a given quantity of urine, so long as a precipitate of sulphate of baryta is formed. It must, however, be observed, that when we have added to a given volume of urine, slightly acidulated with hydrochloric acid, a quantity of chloride of barium exactly equivalent to the sulphuric acid contents, a so-called neutral point is attained, at which the filtrate will yield a slight cloudiness with sulphuric acid as well as with chloride of barium-solution. In a solution of this composition, we must regard the chloride of potassium, the chloride of barium, and the sulphate of potash in a certain state of equilibrium: so that, if more chloride of barium, or sulphate of potass be added, the balance is destroyed, and sulphate of baryta is separated. Hence, in the determination of sulphuric acid in the urine by means of the chloride of barium-solution, we must either add the solution until the neutral point is attained (*i. e.* until a slight cloudiness is obtained by the further addition of a drop of the solution, as well as in another specimen by a drop of sulphate of potash-solution), or we must add the chloride of barium-solution until the presence of only a slight excess of the baryta is indicated in the filtrate by sulphate of potash.

Of course the strength of the chloride of barium-solution must be different, according to which of these two methods of determining the completion of the reaction is employed. If we continue the graduation up to the neutral point, it will be best to concentrate the chloride of barium-solution, so that 1 cubic-centimetre of it shall contain a quantity of baryta equivalent to 10 milligrammes of sulphuric acid; but in the second case, the baryta-solution must contain a slight excess of baryta, in order that each cubic-centimetre shall precipitate 10 milligrammes of sulphuric acid, and the final test-point be indicated by a slight baryta reaction of the filtrate. I am satisfied, that the neutral point is pretty well ascertained, that the result is satisfactory, and that the graduation with sulphuric acid may be considered as complete, when in two test specimens of the clear filtrate a similar slight degree of cloudiness is produced by the chloride of barium, and by the sulphate of potash. Mulder first called attention to this neutral point produced in the graduation of silver by chloride of sodium.

B. *Preparation of the solutions.—a. Chloride of barium-solution.*—This solution is concentrated so that 1 C.C. of it contains exactly 10 milligrammes of sulphuric acid. It is prepared by dissolving 30·5 grammes of crystallised chloride of barium, powdered and air-dried, and diluting the solution up to 1 litre. 1 C.C. of it equals 10 milligrammes of anhydrous sulphuric acid.

FIG. 24.

b. Sulphate of potash-solution.—This solution should be exactly equivalent to the solution of chloride of barium. It is prepared by dissolving 21·77[illegible] grammes of powdered chemically pu[illegible] tash, dried at 100° C[illegible] diluting the solutio[illegible] C.C. will the[illegible] sulphuric [illegible] the ch[illegible]

[illegible]

ide of bari[illegible]

and the mixture allowed to stand until the sulphate of baryta is deposited. It rapidly becomes dense when heated to boiling, and is afterwards perfectly precipitated. When the fluid has become clear, another cubic centimetre of the chloride of barium-solution is added; 10 or 12 drops of the mixture are then heated and filtered through a small filter, into a narrow tube about two inches long, and tested, in order to ascertain whether or not a further precipitate may be obtained by chloride of barium. If the precipitate takes place, we then add to another specimen a few drops of sulphate of potash-solution, and thereby learn whether or not an excess of baryta-solution has been added. If in the first specimen tested a distinct cloudiness has been caused by the baryta-solution, the fluid is poured back into the flask, the filter and tube washed with a little water, and the washings added to the urine. Should, up to this point, about 8 C. C. of the chloride of barium-solution have been used, 1, 2, 3, or 4 more cubic centimetres are added, according to the degree of reaction which follows, which may be readily learnt after a little practice, from observation of the amount of cloudiness which occurs in the first specimen tested. The mixture is then heated until it becomes clear, a few drops again filtered off for testing, and the operation continued until no further cloudiness appears in the filtrate on the addition of chloride of barium. If this point is reached after the employment of 13 C. C., and if an excess of baryta is distinctly shown in a new specimen by sulphate of potash, we know that the true point must lie between 12 and 13 C. C., and that the 100 C. C. of urine must therefore contain between 120 and 130 milligrammes of sulphuric acid.

We then measure off another 100 C. C. of urine, treat them with 20 to 30 drops of hydrochloric acid, add at once 12 C. C. of chloride of barium-solution, boil, and test a few drops of the filtrate with $\frac{1}{10}$ C. C. of baryta-solution. If a distinct cloudiness immediately appears, the filtrate is added to the original fluid, $\frac{3}{10}$ C. C. of baryta-solution added, the filtrate again tested, and the operation repeated until it is found that only a slight degree of cloudiness appears, several seconds after the addition of the chloride of barium-solution. A second specimen of the filtrate is next tested with a few drops of sulphate of potash-solution, and here also, if we find that a slight cloudiness arises in the course of several seconds, the neutral point is attained, and the graduation complete.

[illegible] urine remaining [illegible] diluted up to 200 [illegible] of Fehling's [illegible] with 0·6 [illegible] contained in [illegible]

[illegible]

[illegible] C.C. [illegible]

[illegible] of Fehling's [illegible]

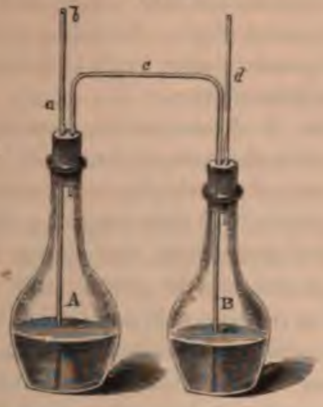
[illegible] C.C. of the original urine [illegible] filtered off from the separated [illegible] were diluted up to 200 C.C. and volumetrically analysed. [illegible]

The same experiments were several times repeated on other days [illegible] worthy of note. [illegible] acetate of lead may be [illegible] so as to [illegible] of the sugar, as [illegible] inappreciably [illegible] be first of all [illegible] of acetic acid, [illegible] carefully washed, and the [illegible] determination of the sugar.

2. *Determination of the Quantity of Sugar by Fermentation.*—*a. Theory.* We have already seen (Section XXI. c. 9) that diabetic urine ferments when yeast is added to it. One equivalent of the sugar is thereby decomposed into 2 equivalents of alcohol, and 4 equivalents of carbonic acid. Hence, therefore, if we ascertain the quantity of carbonic acid which is formed by the fermentation of a given quantity of diabetic urine, we may at once reckon the quantity of sugar present in it. One hundred parts of carbonic acid correspond with 204·54 parts of sugar.

B. *Process.*—In this process we make use of the apparatus shown in Fig. 25. From 20 to 30 C.C. of urine are introduced into the flask, A, and a little well-washed (and so-called) dried yeast added to it, together with a small quantity of tartaric acid. The flask is then united by the bent tube, *c*, with the flask, B, which is half-filled with concentrated sulphuric acid. The tube, *a*, in the flask, A, is closed above by a bit of wax, and the apparatus accurately weighed. It is then subjected to a temperature of about 15° to 25° C. (59° to 77° Fahr.). Fermentation thereupon soon sets in, and carbonic acid is developed. The gas goes off by the tube, *c*, and passes through the sulphuric acid in the flask, B; being thus completely dried, it escapes through the tube, *d*, which may be united with a small V-shaped tube, containing chloride of calcium, in order to prevent any moisture from the air being absorbed by the concentrated sulphuric acid in B.

FIG. 25.



The fermentation is usually completed in the course of two or three days; carbonic acid ceases to be given off, and the whole of the sugar is decomposed. The flask, A, is gently heated to drive off any carbonic acid which may be retained in it, and a little air is then sucked out of the apparatus at *a*, through a hole in the cork, until it no longer tastes of carbonic acid. The apparatus is then once more weighed. The loss of weight gives us directly the quantity of carbonic acid which has been formed during the decomposition, and from this we can readily calculate the corresponding quantity of sugar contained in the urine—48·89 parts of carbonic acid exactly corresponding with 100 parts of diabetic sugar This method is easily practised, though it requires a length of time for completion; but it is liable to several errors. In the first place, according to Jacquemert, normal urine, when treated with yeast, gives off a small quantity of carbonic acid; and then again urine itself, as well as yeast, contains some free carbonic acid. The last source of error may be removed by adding a weighed quantity of yeast to the urine, and ascertaining by a separate experiment how much carbonic acid the yeast itself will give off. This quantity of carbonic acid must then be subtracted.

If the urine contains albumen, the albumen must be coagulated by boiling, otherwise putrefaction may occur, and this is of course attended with development of gas. According to Lehmann the addition of tartaric acid prevents other kinds of decomposition, and also promotes the vinous fermentation.

Lehmann proposes to determine the quantity of sugar in the urine, not directly, after the manner described, but by precipitating it first of all in the form of potash-glucose by means of caustic potash from an alcoholic solution, and then subjecting this to fermentation.

The researches of Pasteur show, that during the fermentation of the sugar, amylic-alcohol, butylic-alcohol, and even succinic acid are formed, as well as carbonic acid and alcohol. Consequently, the amount of carbonic acid is no positive measure of the quantity of the sugar; and this may explain the circumstance, that many chemists have always found less sugar in diabetic urine by the employment of the fermentation test, than by means of Fehling's excellent process. Fehling's method is decidedly the best.

SECTION LXVI.

DETERMINATION OF THE QUANTITY OF IODINE IN THE URINE.

As it is in many cases a matter of interest to ascertain the quantity of iodine in the urine, when any preparation of iodine has been taken, the volumetrical method proposed by Kersting for this object is here introduced (*Annalen der Chemie und Pharm.*, Bd. 87, p. 21).

A. *Theory.*—This method is based on the fact, that the whole of the iodine is separated from a solution, even moderately dilute, of any metallic salt of iodine, by distillation with sulphuric acid, so that, if the distillation be carried on long enough, not a trace of iodine will be left in the residue. The quantity of iodine which passes over with the distillate is measured by a standard solution of proto-chloride of palladium.

If, for instance, a solution of a metallic salt of iodine is mixed with an excess of the proto-chloride of palladium-solution, and a little hydrochloric acid added, at a temperature of from 60° to 100° C. (140° to 212° Fahr.) iodide of palladium will be formed in the course of a few seconds, and on shaking the mixture, will separate in black curdy flocculi, the supernatant fluid remaining perfectly clear and colourless. But if the iodide be in excess, the separation takes place much more slowly, and the iodide of palladium is partly deposited as a dark layer firmly adherent to the side of the glass.

For this reason, in estimating the iodine, we must not add the palladium-solution to the fluid which contains the iodine, but we must measure off a given quantity of the palladium-solution, and then find out the number of cubic-centimetres of the fluid to be tested for iodine, which suffice for the exact precipitation of the known quantity of palladium-solution employed. As the mixture by heat and agitation becomes nearly absolutely clear, and as the presence of from $\frac{1}{30}$ to $\frac{1}{300}$ milligramme of iodine may be shown by palladium; and as on the other hand, $\frac{1}{100000}$ part of palladium yields a distinctly brown colour with iodine—the calculations, as I found, made with pure iodide of potassium and proto-chloride of palladium-solutions, both of known strength, came out very accurately.

B. *Preparations of the solutions.*—1. *Standard solution of iodide of potassium.*—This solution must contain exactly $\frac{1}{1000}$ of iodine, and is readily obtained by weighing off 1·308 gramme of pure iodide of potassium heated to redness, and free from iodate of potash, dissolving it and then diluting the solution up to a litre. 1 C. C. of this solution contains 1 milligramme of iodine, as 1·308 gramme of iodide of potassium exactly corresponds with 1 gramme of iodine $(126{\cdot}88 : 165{\cdot}99 = 1 : x = 1{\cdot}308)$.

This solution serves for the volumetrical determination of the solution of proto-chloride of palladium.

2. *Acid solution of proto-chloride of palladium.*—*a.* The salt of palladium is prepared from the metal. One gramme of palladium,

[illegible] heat in aqua [illegible] dryness: 50 [illegible] added to it, and [illegible] the palladium [illegible] the exact [illegible] iodide of potas-[illegible] part of iodine.

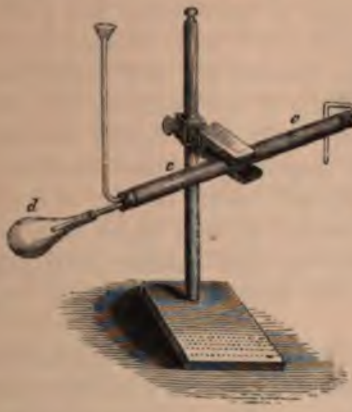
[illegible]—10 [illegible] tested, are [illegible] to 200 [illegible] heated in a water-[illegible]. The iodide-[illegible] the pipette, the [illegible]. A small [illegible] of a few [illegible] so that [illegible]. To one of [illegible] added, and the [illegible] become of a [illegible] are returned [illegible] iodide-solution is [illegible] again tested as before. [illegible] produce any [illegible] of the fluid [illegible] palladium- and [illegible] discolora-[illegible] of these bodies. [illegible] appear, it may [illegible]. The quantity of palla-[illegible] from the [illegible] which have been employed.

1 C.C. of the iodide-solution contains 1 milligramme of iodine, and this corresponds with 0.42 milligramme of palladium (126·[illegible] : 53·24 = 1 : x = 0·42.)

If then, for example, 11.9 C.C. of iodide-solution have been used in the precipitation of 10 C.C. of the proto-chloride of palladium-solution, they will correspond (as they contain exactly 11·9 milligrammes of iodine) with 11.9 × 0.42 milligrammes of palladium. 10 C.C., therefore, of palladium-solution contain 4.998 milligrammes of palladium, and require just the quantity of any iodine-solution of unknown strength, which contains 11·9 milligrammes of iodine. In this way the amount of iodine contained in the whole of the fluid may be easily reckoned.

c. *Process.*—In order to ascertain the quantity of iodine present in the urine, it is first of all necessary to separate it by distillation with sulphuric acid. For this purpose the apparatus here represented is used. (Fig. 26.)

FIG. 26.



a is a glass-flask, containing about 300 C. C.; it is united by a bent glass-tube, with a Liebig's condenser, *c c*, in which the vapour is condensed, and from whence it passes into the glass, *d*, which acts as a receiver. If the urine contains a distinctly appreciable amount of iodine, we measure off from 50 to 100 C. C. of it with a pipette, and introduce this quantity into the flask, *a*, which is placed in cold water; we then carefully drop into it 20 C. C. of pure concentrated sulphuric acid free from iodine, taking care to avoid the development of a great heat. The flask is then fixed to the condenser, and the distillation of the fluid carried on until a white vapour of sulphuric acid begins to show itself in the neck of the flask.

If, however, the urine contains only a very small quantity of iodine a measured quantity of it, say 200 to 250 C. C., is treated with an excess of caustic potash, and then distilled down to about 20 or 40 C. C. The distillate contains no iodine. 20 C. C. of concentrated sulphuric acid are now cautiously added to the residue [illegible] by this [illegible] permanganate [illegible] potash, [illegible] permanganate [illegible] per [illegible] solution [illegible] : it is [illegible] the pre- [illegible] the perman- [illegible] to saturate [illegible]

[illegible] if the are [illegible] tempera- [illegible] permanganate [illegible] combinations.

[illegible]

[illegible]

[illegible] zinc, [illegible] Zn Cl, [illegible] slightly [illegible] according to my [illegible] determina- [illegible] parts of [illegible] parts of crea- [illegible]

[illegible] parts of [illegible] parts [illegible] per cent., [illegible]

3. [illegible] —Chemically-pure [illegible] hydro- [illegible] thick syrup in a [illegible] completely driven off. [illegible] moderately strong [illegible] has a specific gravity of 1·2[illegible].

and 10 equivalents of protoxide are thereby converted into peroxide of iron. If, now, the strength of the permanganate of potash-solution be known, we can thereby easily calculate any unknown quantity of iron (which must necessarily exist in solution as protoxide), by measuring the volume, which exactly suffices for its oxidation. The completion-point of the operation is clearly indicated by the bright-red colour of the whole of the fluid, which is produced even by one drop of permanganate of potash added in excess.

B. *Preparation of the solutions.*—1. *Solution of permanganate of potash.*—A highly concentrated solution of 10 parts of hydrate of potash is added to 8 parts of peroxide of manganese and 7 parts of chlorate of potash well-mixed together, and the mixture evaporated to dryness; the mass is then put into a crucible, and gently heated up to a moderate red-heat, until all the chlorate of potash is decomposed. The green mass thus obtained, rubbed up with water, is boiled until the green colour of the manganate of potash has passed into the violet colour of permanganate of potash, peroxide of manganese being separated. The precipitate is separated by decantation, and the clear solution, which must be filtered through asbestos, preserved in a well-closed bottle.

The strength of the permanganate of potash-solution must be ascertained before every experiment, for, in spite of the greatest care, it is liable to undergo a change. The volumetrical analysis of it is very simply performed with a solution of ferrocyanide of potassium, 10 equivalents of which are converted into 5 equivalents of ferridcyanide of potassium by 1 equivalent of permanganic acid. Consequently, 1 equivalent of ferrocyanide of potassium (211·2) corresponds with 1 equivalent of iron (28).

2. *Solution of ferrocyanide of potassium.*—7·543 grammes of pure, dry, crystallised ferrocyanide of potassium, corresponding with 1 gramme of iron, are dissolved in water, and the solution diluted to a litre. 10 C.C. of this solution correspond exactly with 0·010 gramme of iron. The solution must be kept in a well stoppered bottle.

Graduation of the permanganate of potash-solution.—10 C.C. of the ferrocyanide of potassium-solution (corresponding with 10 milligrammes of iron) are measured off with the pipette, diluted with about 50 C.C. of water, and acidified with hydrochloric acid; the glass containing the mixture is then placed upon a sheet of white paper, and the dilute solution of permanganate of potash dropped into it, shaking the mixture from time to time, until the yellowish-red colour of the fluid announces the completion of the operation. If 20 C. C. of permanganate of potash-solution have been used in this operation, 1 C. C. of it will correspond with $\frac{0{\cdot}010}{20} = 0{\cdot}5$ milligramme of iron. The experiment should be confirmed by a second experiment.

A solution of oxalic acid, containing 1·125 gramme of crystallised oxalic acid in a litre, and corresponding with 1 gramme of iron, will serve for the same purpose. 10 C. C. of this solution, corresponding with 0·010 gramme of iron, are measured off, and heated to boiling, treated with a little dilute sulphuric acid, and graduated with the permanganate of potash-solution until the red colour appears. The volume employed for this purpose will correspond with 0·010 gramme of iron. Of these methods, I prefer the last.

c. *Process.*—In order to ascertain the quantity of iron in the urine by this method, it is necessary to evaporate the urine, and burn off the organic matter. For this purpose 100 C. C. of urine are evaporated to dryness in a platinum basin, and heated to perfect carbonization; the ash is then burnt until the whole of the carbon is driven off, and the residue has become perfectly white. When cool the saline mass is dissolved in hydrochloric acid, and heated; water is added to it, and the solution carefully poured into a flask which will hold from about 100 to 150 C. C.

Before the graduation can be effected the iron, which exists as peroxide, must be reduced. A little sulphite of soda is therefore added to the hydrochloric acid solution, and the solution boiled until the fluid becomes colourless, and no trace of sulphurous acid can be discovered in it. Having ascertained the strength of the permanganate of potash-solution by means of the oxalic acid-, or ferrocyanide of potassium-solution, we dilute the solution of iron to about 60 C. C., and when it is perfectly cool place the glass containing it on a sheet of white paper, and drop into it the permanganate of potash-solution until the fluid assumes a pale rose-red colour. If, now, 1 C. C. of the permanganate of potash-solution corresponds with 0·0005 gramme of iron, and if 3 C. C. were employed in the operation, the 100 C. C. of urine will contain 3 × 0·5 milligrammes of iron = 0·0015 gramme. The quantity of iron thus obtained multiplied by 1·43 gives the corresponding quantity of peroxide, and multiplied by 1·286 the corresponding quantity of protoxide.

This method is good, and gives accurate results. It must be remembered, however, that the red colour produced by the last drop added, disappears after a little time, and may so lead the incautious observer into error.

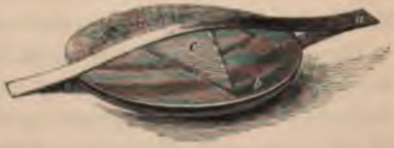
SECTION LXVIII.

DETERMINATION OF THE URIC ACID IN THE URINE.

A. *Precipitation by hydrochloric acid.*—200 C.C. of urine are introduced into a small beaker-glass, and 5 C.C. of pure hydrochloric acid (sp. gr. 1·11) added to it; the mixture is well stirred with a glass rod, the beaker-glass covered with a glass-plate, and allowed to stand at rest in a cellar at as low a temperature as possible for about twenty-four or thirty-six hours. At the end of this time, the uric acid is found separated in the form of more or less coloured crystals. These must be collected on a weighed filter and dried.

As, however, paper is very hygroscopic, the weight of a dried filter cannot be directly determined. We, therefore, in this as in all other cases in which substances, whose quantity is to be ascertained, are collected on weighed filters, make use of a simple arrangement which fully answers the purpose. Two watch-glasses (Fig. 27, *b b*,) ground at the edges and exactly fitting to each other, are firmly held together by a brass clip, *a a*, so that a filter, *c*, lying between them is hermetically enclosed. The two watch-glasses with the filter lying on them and the brass-clip are introduced into the drying apparatus (Fig. 10). When this has been kept for some time at a temperature of 100° C. (212° Fahr.) the watch-glasses containing the filter are laid together, the clips slipped over them, and when cooled in the sulphuric acid apparatus (Fig. 11), are weighed.

FIG. 27.



The uric acid is collected on a filter thus dried, in the following way. The crystals on the surface of the fluid are first poured off on to the filter, and the remainder of the urine, which is generally clear, is

100° C. (212° Fahr.) until (after being dried over oil of vitriol) it ceases to lose in weight.

Great care must be taken that the albumen is not dried up into a horny mass, with a dry crusted surface, which sometimes happens, in consequence of too large a quantity of it being employed. In such case some of the moisture remains enclosed within it, and takes a long time (six to eight hours) before it is driven off at 100° C. (212° Fahr.). The drying operation can only be considered as complete, when the filter and its contents, weighed at different intervals of the drying, give the same results. By abstracting the original weight of the watch-glasses and the filter from the weight thus obtained, we learn the quantity of albumen present, and can thereby calculate the quantity for the whole of the urine.

Two sources of error are connected with this method of determining the quantity of albumen. In the first place, the albumen during its coagulation, abstracts from the urine a part of its colouring-matter, which cannot be afterwards separated from the albumen even by long washing with boiling water. Hence the albumen is in most cases when dried of a yellow, or rather of a brownish, colour. This cause of error is, however, very insignificant, and need not be taken into consideration. In the second place, earthy phosphates are frequently separated with the albumen, and consequently the quantity of albumen appears too great. If, therefore, very accurate calculations are required, the dried and weighed albumen must be burnt with the filter in a platinum capsule of known weight, and all the carbon driven off by heat,—which may be readily effected in a capsule inclined at the proper degree. The increase of the weight of the capsule, minus the known weight of the ash of the filter, gives the ash-contents of the weighed albumen, which must be subtracted from the quantity of albumen as first obtained.

In most cases this additional process is not required. I have fully satisfied myself, that the quantity of ash obtained from albumen coagulated out of sufficiently diluted acid urine, is very small, and has scarcely an appreciable influence over the result.

20 C.C. of highly albuminous urine are diluted with 80 C.C. of water, in a beaker-glass, and coagulated in a water-bath. The coagulum is collected on a folded filter, thoroughly washed and dried at 100° C. (212° Fahr.), until the weight is constant. The albumen weighed 0·3573 gramme, which for the whole twenty-four hours' quantity of urine (1050 C.C.), gave 18·76 grammes. After

incineration, and deduction of the ash of the filter, 0·0013 gramme of ash remained to represent the albumen. After subtracting this, the twenty-four hours' quantity of urine amounted to 18·69 grammes instead of 18·76 grammes, as first obtained.

A. *Volumetrical Analysis.—Theory.*—This method, proposed by Bödeker, is based upon the fact, that albumen is completely precipitated from an acetic acid solution by ferrocyanide of potassium. According to Bödeker, one equivalent of albumen ($C_{144} H_{112} N_{18} O_{44} S_2$ Equiv. 1612) requires for its precipitation one equivalent of ferrocyanide of potassium (Equiv. 211).

B. *Preparation of the ferrocyanide of potassium-solution.*—1·309 gramme of chemically pure ferrocyanide of potassium, air-dried, and which has not effloresced, is dissolved in water, and the mixture diluted up to a litre. 1 C.C. of this solution precipitates 0.01 gramme of albumen from an acetic acid solution.

C. *Process.*—The filtered urine is mixed with an equal volume of acetic acid (concentrated acetic acid), and a burette filled with the mixture. Six filters, made of carefully selected paper, are prepared for use, being placed on funnels, sprinkled with acetic acid, and washed three or four times with boiling water. The subsequent filtration is thereby rendered more rapid and complete.

5 C.C. of the albuminous solution are then mixed with 5 C.C. of the ferrocyanide of potassium-solution, and the mixture, after a long and thorough shaking, poured upon the first filter. If the ferrocyanide of potassium is in excess, the mixture passes through the filter clear, is of a pale yellow, and the filtrate is not precipitated by ferrocyanide of potassium; but it is precipitated, or rendered flocculent, by the albuminous solution. If the albumen, however, is in excess, the filtered mixture is somewhat cloudy, or it passes slowly, and then it is found that the filtrate is rendered cloudy or precipitated, not only by the ferrocyanide of potassium, but also, and curiously enough, by the acid albuminous solution. Too much of the albuminous-solution, however, must not be added to the specimen of the filtrate, which is tested for an excess of ferrocyanide of potassium; for in such case the precipitate of hydroferrocyanide of albumen is completely dissolved in an excess of albumen.

According to the result obtained from the first tested specimen, a second one is prepared, in which either the quantity of albuminous solution, or of the ferrocyanide of potassium-solution added is doubled. In this way we proceed until we find that the solution, of which too little has up to this time been added, is in excess. Each new testing, with an intermediate quantity, renders the limits narrower and narrower, until the experiment is sufficiently accurate. Rarely have we to make more than five or six experiments; and if we only desire an approximate idea of the quantity of the albumen in the fluid, three, or at most four, tests suffice.

Example.—50 C. C. of albuminons urine are diluted to four times their volume by the addition of 150 C. C. of dilute acetic acid:

			The filtrate gave—	
	The four times diluted urine.	Ferrocyanide of Potassium.	Albumen.	Ferrocyanide of Potassium.
1.	20 C. C.	5 C. C.	0	Precipitate.
2.	20 C. C.	10 C. C.	Precipitate	0
3.	20 C. C.	7·5 C. C.	0	Cloudiness.
4.	20 C. C.	8·8 C. C.	0	Turbidity.
5.	20 C. C.	9·4 C. C.	Slight cloudiness	0
6.	20 C. C.	9·1 C. C.	0	0

In controlling these results, it was found that—

7.	20 C. C.	9·0 C. C.	0	After a short time, opalescence.
8.	20 C. C.	9·2 C. C.	After a short time, opalescence.	0

Thus, 20 C. C. of the four-times diluted urine, or 5 C. C. of the original urine, contain (according to the 6th testing) 10 × 9·1 = 91 milligrammes of albumen, from which the whole quantity contained in the twenty-four hours' urine may be readily calculated.

This method yields only approximate results, consequently the process by weighing is preferable to it, and if accurately carried out, after the manner already described, is both convenient and safe.

SECTION LXXI.

LIME AND MAGNESIA.

I. Determination of the Lime in the Urine.

A. *Volumetrical method.—Theory.*—This method of estimating the lime in the urine is founded on the fact, that the whole of the lime is precipitated as an oxalate by oxalate of ammonia, from a solution of phosphate of lime rendered acid by acetic acid; and that oxalate of lime passes at a red-heat into the form of carbonate of lime and caustic lime, whose amount may be ascertained by standard solutions of hydrochloric acid and soda.

B. *Preparation of the solutions.*—1. *Standard hydrochloric acid.*—Each C. C. of hydrochloric acid-solution, employed for the purpose of estimating the lime, should be so prepared as to correspond exactly with 10 milligrammes of lime. Consequently, 1 litre of the acid should saturate 10 grammes of lime, or 18·93 grammes of carbonate of soda. To prepare this solution we weigh off two portions—about 1 to 1·2 gramme—of pure carbonate of soda, which has been previously heated to redness. Each portion is dissolved separately in water in a flask, and heated to boiling, after adding a few drops of tincture of litmus; dilute hydrochloric acid is then added until the blue colour has passed into a pale red, which does not disappear with continued boiling. The object of the boiling is to drive off the free carbonic acid, in order that the passage of the wine-red (produced by the carbonic acid) into the pale red, may be distinctly seen.

The experiment is repeated with the second portion of carbonate of soda, and by taking the mean of the two results we ascertain the quantity of hydrochloric acid in a litre. If, for instance, we find that 1 litre of hydrochloric acid corresponds with 41·6 grammes of carbonate of soda, 457 C. C. will saturate exactly 18·9 grammes. If, therefore, we measure off 457 C. C. of the hydrochloric acid thus proved, and dilute it up to a litre, the acid will have the desired strength. 1 C. C. corresponds with 0·0189 gramme of NaO, CO_2, or with 0·010 gramme of CaO. The accuracy of the dilution should be ascertained by a confirmatory testing with carbonate of soda.

2. *Standard soda-solution.*—The soda-solution must accurately correspond with the hydrochloric acid, that is to say, 10 C.C. of it must exactly saturate 10 C.C. of hydrochloric acid, so that on the addition of the last drop of the 10 C.C. of soda-solution, the red colour of the hydrochloric acid shall pass into a clear blue. Especial care must be taken that the soda-solution is perfectly free from carbonic acid, otherwise the change of colour will not be distinctly marked. 10 C.C. of hydrochloric acid are measured off by the pipette, and introduced into a beaker-glass, and coloured with a few drops of tincture of litmus. The soda-solution is then added until the mixture turns blue.

Suppose 8 C.C. of soda-solution have been employed to the 10 C.C. of hydrochloric acid, we measure off 800 C.C. of the soda-solution, and dilute up to a litre. Equal volumes of the two will now exactly saturate each other. The correctness of the dilution should be proved by a second trial; if, after the last drop of the 10 C.C. of soda-solution has been added, the red colour of the 10 C.C. of hydrochloric acid changes into a clear blue, the soda-solution is fit for use.

c. *Process.*—100 to 200 C.C. of the previously filtered urine are accurately measured off with a pipette, and introduced into a beaker-glass; ammonia is added until a large precipitate is thrown down, and the precipitate then re-dissolved by the careful addition of acetic acid. From the acetic acid-solution (which must contain but a few drops of the acid in excess) thus obtained, the lime is thrown down by oxalate of ammonia, and the glass allowed to stand (covered) in a warm place, until the whole of the precipitate has been deposited, and the supernatant liquor has become perfectly clear.

In most cases the clear fluid may be drawn off by a syphon in the course of six or eight hours, and when this can be done without loss, it saves the trouble of filtering. The remains of the fluid, with the oxalate of lime, is poured on a small filter, free from lime, and thoroughly washed with hot water. The filtrate and the water washings are to be set aside for the calculating of the magnesia.

The filter, still moist, is, with the precipitate, now placed upon a small platinum crucible, dried, and heated, until the whole of the carbon is consumed. The lime, which is in part in a caustic state, is carefully introduced into a small flask, 10 C.C. of the standard hydrochloric acid added, and carefully heated, until the whole of it is dissolved, and the carbonic acid driven off. The solution is then coloured of a light red by the addition of four to six drops of tincture of litmus, and the free hydrochloric acid saturated with the standard soda-solution until the blue colour returns.

If, at this point, we subtract from the 10 C. C. of hydrochloric acid which have been added, the number of cubic centimetres of soda-solution employed, we obtain the number of cubic centimetres which have been saturated by the lime, each cubic centimetre corresponding with 10 milligrammes of lime. Thus, if we multiply by 10 the number of saturated cubic centimetres of hydrochloric acid, we obtain directly the per-centage quantity of lime in the urine, provided 100 C. C. have been employed in the experiment. (See Analytical Proofs.) If we wish to reckon the lime as phosphate, then 1 C. C. of hydrochloric acid corresponds with 18·45 milligrammes, $3\,CaO, PO_5$.

Determination of the lime by weight.—We proceed as before, precipitating the lime as an oxalate from 200 C. C. of filtered urine, acidulated with acetic acid. The oxalate of lime, well washed and dried, is removed from the filter into a platinum crucible, and exposed for some time to a strong red-heat, the filter being also reduced to an ash. When the crucible is cool, the lime, which has been in part brought to the state of caustic lime by the heat, is then moistened with a few drops of pure sulphuric acid, the crucible being closely covered, in order to prevent any loss. On being again heated, the lime remains as sulphate. The crucible is then allowed to cool and is weighed. By subtracting the weight of the crucible and the ash of the filter, we obtain the quantity of sulphate of lime, and from this may calculate the corresponding quantity of phosphate of lime.—The conversion of the oxalate of lime into sulphate of lime, by heating it with pure sulphate of ammonia, is more convenient than the evaporating and heating with sulphuric acid. (*Schrötter.*)

As three equivalents of sulphate of lime correspond with one equivalent of phosphate of lime of the composition $3\,CaO, PO_5$, we multiply the quantity of sulphate of lime obtained by $\frac{155}{204} = 0{\cdot}7598$, and thus obtain the corresponding quantity of phosphate of lime. If, on the other hand, we wish to calculate the sulphate of lime as CaO, we multiply the quantity obtained by 0·4118.

II. Determination of the Magnesia.

1. *By Weight.*—The fluid which has been separated by filtration from the oxalate of lime, is treated with ammonia until it yields an alkaline reaction; in this way the whole of the magnesia is thrown down as ammonio-phosphate of magnesia. The precipitate, after being left at rest for some hours, is collected on a filter (whose ash is known), and well washed with water, to which one-fourth of ammonia has been added, and dried. The precipitate is then removed as completely as possible from the filter, and put into a weighed platinum capsule. The filter is folded up, a fine platinum wire twisted spirally round it, and burnt in the outer portion of the flame.

By this process the operation with the phosphate of magnesia, which is otherwise very tedious, is much simplified. The ash, in a very short time becomes perfectly pure and white, and when the combustion is complete, is added to the precipitate. The crucible is then covered with the lid, and exposed for some time, first to a very gentle heat, and afterwards, the lid being removed, to bright redness. It is then cooled over sulphuric acid and weighed.

Organic matters, and particularly uric acid, are always mixed with the ammonio-phosphate of magnesia, thrown down in this way, and they produce a carbon difficult of combustion; consequently, it is necessary to expose the precipitate for a long time to a red heat in an open crucible. For this purpose, it is convenient, after burning the filter in the manner described, to lay upon the ammonio-phosphate of magnesia contained in the crucible, a small bit of nitrate of ammonia moistened with a drop of water, then to dry; heating at first very gently, and at last to redness. The carbon now completely disappears, and we thus readily obtain the phosphate of magnesia as a dazzling white mass. The ammonio-phosphate is converted by heat into a pyro-phosphate of magnesia ($2\,MgO, PO_5$).

After abstracting the weight of the crucible and of the ash of the filter, the remainder, added to the quantity obtained of the phosphate of lime, gives the entire quantity of earthy phosphates in the urine examined. If we wish to calculate the pyro-phosphate of magnesia as pure magnesia (MgO), we must multiply the quantity obtained by $\frac{40}{111}$, that is, by 0·3604; 111 of pyro-phosphate of magnesia corresponding with 40 of pure magnesia.

2. The earthy phosphates may be more conveniently and quickly determined in two different quantities of urine in the following way:—

a. The quantity of phosphate of lime ($3\,CaO, PO_5$) contained in 200 C. C. of filtered urine is accurately determined in the manner described (Section LXXI. C.)—1 C. C. of saturated hydrochloric acid corresponds with 18·45 milligrammes of phosphate of lime.

b. Other 200 C. C. of filtered urine are precipitated with ammonia, and set aside for six or twelve hours in order to allow of the complete separation and precipitation of the whole of the earthy phosphates. The fluid is then removed, as far as possible, with a syphon; the precipitate collected on a filter the weight of whose ash is known, and washed with ammoniated water (3 parts water to 1 part ammonia). The process is then completed as described under the head of Magnesia (Section LXXI. II. 1).

This second estimation gives the whole quantity of the earthy phosphates ($2\,MgO, PO_5$ and $3\,CaO, PO_5$) contained in the urine. If we subtract therefrom the phosphate of lime contained in the urine first examined (*a*), the remainder will represent the quantity of phosphate of magnesia in the urine.

3. *By volumetrical analysis*.—The magnesia is precipitated by ammonia from 200 C. C. of urine, after the lime in it has been first separated by means of oxalate of ammonia. In the course of a few hours the ammonio-phosphate of magnesia is collected on a small filter and washed with ammoniated water. The filter is then broken with a glass rod, and the precipitate washed through into a beaker-glass and dissolved in acetic acid. Should (as often happens) a little uric acid remain behind, it is best separated from the solution by filtration. The quantity of phosphoric acid in the fluid thus obtained is then accurately determined (see Section LXI. C. *b*). The quantity of phosphoric acid obtained, multiplied by 0·563, and the corresponding quantity of pure magnesia (MgO) multiplied by 1·563, give the corresponding quantity of pyro-phosphate of magnesia.

III. Indirect Determination of the Lime and Phosphate of Magnesia.

In indirect analysis no actual separation is aimed at, but other conditions are obtained, by means of which the acids and bases found in combination can be calculated. If, for example, we wish to determine potash and soda together, the analysis may be conducted in such a manner that both of them are converted into sulphates. By weighing these sulphates, and determining the quantity of sulphuric acid contained in them, we can calculate the quantity of soda and of potash.

The same holds good as regards the lime and magnesia, combined with phosphoric acid in the urine. To carry out the calculation, the earthy phosphates in two specimens, each of 200 C. C., of the filtered urine are precipitated by ammonia, and the fluid filtered off in the course of a few hours. In one specimen the weight is analytically determined as described above (Section LXXI. II. 1). The other specimen is washed into a beaker-glass, dissolved in acetic acid, and the phosphoric acid in it then volumetrically determined (See Section LXI. C. *b*). The results are then calculated for the twenty-four hours' urine. We now know:—

a. The sum of the earthy phosphates

$$\left.\begin{matrix} 3\,Ca\,O,\,PO_5 \\ 2\,Mg\,O,\,PO_5 \end{matrix}\right\}\text{ in the twenty-four hours' urine.}$$

b. The sum of the phosphoric acid corresponding with the twenty-four hours' lime and magnesia.

An example will best explain the calculation.

Suppose the above calculations had shown that the twenty-four hours' urine contained 1 gramme of earthy phosphates, and that the phosphoric acid combined with the earths amounted to 0·579 gramme. The quantity of phosphate of lime and of phosphate of magnesia may, consequently, be obtained in the following way:—

If all the phosphoric acid had been combined with the lime, the earthy phosphates would weigh 1·264 gramme, according to the following proposition:—

$$71 : 155 :: 0{\cdot}579 : x.$$

$$(\text{Equiv. } P\,O_5) \qquad \text{Equiv. } 3\,Ca\,O,\,P\,O_5 \qquad \left\{\begin{matrix}\text{Quantity of phos-} \\ \text{phoric acid found.}\end{matrix}\right.$$

$$x = 1{\cdot}264 \text{ gramme.}$$

As, however, the whole of the earthy phosphates weigh less (viz., 1 gramme), phosphate of magnesia is present, and forms a proportionate part of the difference

$$1{\cdot}264 - 1{\cdot}000 = 0{\cdot}264.$$

This quantity of phosphate of magnesia is obtained in the following way:—

44 : 111 : : 0·264 : x. $x = 0·666$ gramme $2\,MgO, PO_5$.

Thus we have:—

The whole of the earthy phosphates - - - - = 1·000 gramme.
The calculated quantity of phosphate of magnesia = 0·666 gramme.
Remains, therefore $3\,CaO, PO_5$ = 0·334 gramme.

From these details the following short method of calculation, applicable in all cases, may be deduced:—

The phosphoric acid contents of the mixture are multiplied by 2·1831, the sum of the earthy phosphates abstracted from the product, and the remainder multiplied by 2·5227; in this way is obtained the phosphate of magnesia contained in the mixture.

If we represent the sum of the earthy phosphates obtained by S, and the phosphoric acid obtained by P, the calculation may be simply expressed in the following formula:—

$$(P \times 2·1831 - S)\ 2·5227.$$

Then, if we wish to calculate the lime and magnesia in the quantities of phosphate of lime and phosphate of magnesia obtained, we use the following formula:—

$$3\,CaO, PO_5.\ \ 0·5420 = CaO.$$
$$2\,MgO, PO_5.\ \ 0·3604 = MgO.$$

SECTION LXXII.

Determination of the Ammonia in the Urine.

A. *Theory.*—This method of determining the quantity of ammonia in the urine, first proposed by Schlösing, is founded on the fact: that an aqueous solution containing free ammonia, loses its ammonia by evaporation in the air at ordinary temperatures, and in a comparatively short space of time, and that dilute sulphuric acid absorbs the whole of the ammonia contained in a closed space. If, therefore, we place an aqueous solution of ammonia together with a measured quantity of standard sulphuric acid in a closed space, the whole of the ammonia will in a short time enter into combination with the sulphuric acid, and saturate an equivalent amount of it. The quantity saturated may be readily ascertained by the volumetrical determination of the non-saturated portion of the sulphuric acid with a standard soda-solution.

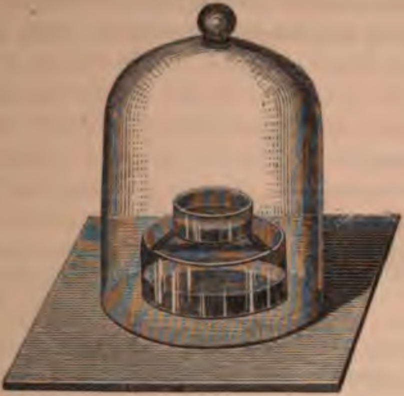
B. *Preparation of the solutions.*—1. *Standard sulphuric acid.*—Fourteen grammes of hydrated sulphuric acid are diluted with 200 grammes of water; and when the mixture is cool, we ascertain in the usual way by two experiments with 10 C.C. of urine, through precipitation with chloride of barium, the strength of this dilute acid. If the two analyses agree, we may accept the result as correct. If, for example, we find that 10 C.C. of the diluted acid contain 0·505 gramme of sulphuric acid, they will then be exactly saturated by 0·2146 gramme of ammonia (NH_3). Consequently, 1 C.C. of the dilute acid corresponds with 0·02146 gramme of ammonia (NH_3).

2. *Standard soda-solution.*—We ascertain the volume of a carefully prepared solution of soda, free from carbonic acid, which is required to saturate 10 C.C. of the standard sulphuric acid. For this purpose, 10 C.C. of the standard sulphuric acid are introduced into a small beaker-glass, a few drops of litmus-tincture added, and the soda-solution dropped into it from a pipette, until the fluid becomes blue. If 30 C.C. of soda-solution have thus been used, we know, that each cubic centimetre of it corresponds with 0·00715 gramme of ammonia, because 10 C.C. of the sulphuric acid (corresponding with 0·2146 gramme, NH_3) have been exactly saturated by 30 C.C. of soda-solution.

C. *Process.*—A flat glass or porcelain cup—a beaker for instance about one inch high—is placed upon a plate of ground glass, which is smeared with grease; and 10, or what is better, 20 C.C. of urine, which is to be tested, freed from mucus by filtration, introduced into it. A triangle, made of a glass rod, is then laid upon the cup, and upon the triangle is placed a flat shallow vessel containing 10 C.C. of the standard sulphuric acid. A bell-glass having its edges ground, and smeared with grease, is then placed over the apparatus, so as to enclose an hermetically confined space. The whole apparatus is displayed at Fig. 28.

To perform the operation, the bell-glass is raised, and a sufficient quantity of milk of lime (10 C.C.) is added quickly to the urine from a pipette, and the glass cover immediately replaced. In the course of forty-eight hours the whole of the ammonia is driven off from the 10 or 20 C.C. of urine and absorbed by the sulphuric acid. By volumetrically measuring the non-saturated sulphuric acid with soda-solution, we ascertain the quantity which has been used in saturating the ammonia, and, consequently, the quantity of ammonia in the 20 C. C. of urine.

FIG. 28.



Example.—10 C. C. of sulphuric acid = 0·505 gramme, $S\,O_3$ = 0·2146 gramme $N\,H_3$. The same also require 30 C. C. of soda-solution; hence 1 C. C. of soda-solution corresponds with $\frac{0 \cdot 2146}{30}$ = 0·00715 gramme, $N\,H_3$.

At the end of the experiment, we find that 26 C. C. of soda-solution have been required in the process. Consequently, a quantity of $N\,H_3$ is developed, corresponding with 4 C. C. of soda-solution. The 20 C. C. of urine, therefore, contain 4 × 0·00715 = 0·0286 gramme of $N\,H_3$ = 1·43 gramme, $N\,H_3$ p. m.

My own experiments show that fresh healthy urine does not undergo alkaline fermentation in forty-eight hours, but these experiments must not be taken as true in all cases, for as we well know, some kinds of urine very soon become alkaline. It is, therefore, always better to make a counter experiment, by placing a similar quantity of urine, to which milk of lime has not been added, in a second apparatus, and observing what changes take place in it. If we find that the urine readily undergoes decomposition, it is then desirable, first of all, to separate the colouring and extractive matters. And for this purpose we prepare a mixture of a solution of sugar of lead and basic acetate of lead—an equal quantity of each; measure off 30 C. C. of the urine, and add to it an equal quantity of the lead solution, filter the mixture, and then take from the [illegible] 40 C. C., corresponding with 20 C. C. of urine, for the [illegible] of the ammonia. With perfectly fresh urine, as I have [illegible] precaution is not necessary (*Journ. f. prakt. Chemie*, [illegible]). This process gives very satisfactory results. (See [illegible]

SECTION LXXXIII.

DETERMINATION OF THE AMMONIA AND POTASH BY MEANS OF BI-CHLORIDE OF PLATINUM.

A measured quantity, 20 to 30 C. C., of urine are introduced into a beaker-glass, and a sufficient quantity of bi-chloride of platinum, and a volume three times as large of a mixture of alcohol and ether added thereto. The precipitate formed is removed by filtration in the course of twenty-four to thirty hours, well washed with alcohol, to which a little ether has been added, and dried. The precipitate, together with the filter, is then placed in a platinum crucible, and heated to redness, the crucible being at first covered, until the carbon of the filter is wholly consumed, a proceeding which may be much hastened by giving the crucible a slanting position. The remaining mass is treated with hot dilute hydrochloric acid, so long as the acid takes anything up; the platinum which remains behind is then placed on a filter, whose ash is known, carefully washed with boiling water, and the filtrate preserved for the calculation of the potash, as will be presently explained. After heating and weighing, we now obtain the quantity of platinum (the ash of the filter and the weight of the crucible being first subtracted), which corresponds with the amount of potash and ammonia together contained in the urine.

In order to determine the quantity of the potash, the hydrochloric acid solution, together with the washing water, which contains the whole of the potash, is reduced by evaporation to a small volume (1 to 2 C. C.); this is then precipitated by 30 drops of bi-chloride of platinum-solution and a mixture of alcohol and ether as above-mentioned. After twenty-four hours, the precipitate, which contains all the potash in the form of potasso-chloride of platinum, is placed on a filter, washed with alcohol and ether, dried, and burnt together with the filter; hydrochloric acid is then added to it to extract its soluble part; the remaining platinum collected on a filter (whose ash is known), dried, heated to redness, and weighed.

By deducting the ash of the filter we obtain the quantity of platinum, which corresponds with the quantity of potash. The difference between this quantity of platinum, and that which was first obtained, corresponds with the quantity of ammonia. Thus, for example, if we find the total quantity of platinum to be 0·1980 gramme for the potash and ammonia in 30 C. C. of urine, and (in a second calculation) the quantity for potash only 0·1330, the quantity which remains for the ammonia is 0·065 gramme of platinum (0·1980 − 0·1330).

100 parts of platinum correspond with 17·182 parts of ammonia; consequently 0·065 platinum $(100 : 17{\cdot}182 :: 0{\cdot}065 : x)\ x = 0{\cdot}0116$ ammonia in 30 C. C. of urine.

In like manner we reckon, from the quantity of platinum employed in separating the potash, the quantity of potash present in the urine; 100 parts of platinum corresponding with 47·61 parts of potash.

SECTION LXXIV.

DETERMINATION OF THE POTASH AND THE SODA.

A. *Direct determination.*—30 C. C. of urine are mixed with 30 C. C. of baryta-solution (composed of 2 vols. of baryta-water and 1 vol. of cold saturated solution of nitrate of baryta. See Section LX., B. 3.) The mixture is allowed to stand for some time, and filtered; 40 C. C. of it, corresponding with 20 C. C. of urine, are then measured off, and evaporated to dryness in a platinum capsule in a water-bath. The residue is then heated, at first gently, and then strongly, and the heat continued until the greater part of the carbon has undergone combustion.

The operation is facilitated by moistening the burnt mass with a little pure nitric acid; but we must guard against over-heating, lest a portion of the metallic chlorides be thereby driven off.

The residual mass is then extracted with boiling water, and treated (without previous filtration) with a solution of carbonate of ammonia as long as a precipitate is thrown down, the mixture filtered, and the precipitate thoroughly washed, and the filtrate, acidulated with hydrochloric acid, evaporated to dryness in the platinum capsule. The residue, when thoroughly dry, is heated, to drive off the ammoniacal salts, but very carefully, in order that no loss may result from decrepitation. The residue is again dissolved in a little water, and a few drops of ammonia and carbonate of ammonia added, the mixture filtered, the precipitate carefully washed, and the filtrate again evaporated to dryness in a previously-weighed platinum capsule. The thoroughly-dried residue is gently heated to drive off the ammoniacal salts, left to cool in an exsiccator, and weighed.

We thus obtain the whole of the potassium and sodium in combination with chlorine. To separate the two, the alkaline chlorides, when weighed, are dissolved in a little water, bi-chloride of platinum added in considerable excess, and the mixture evaporated almost to dryness in a water-bath. The residue is then treated with spirits of wine (80 per cent.), and allowed to stand for some hours, being frequently well shaken. As soon as the whole of the sodio-chloride platinum is dissolved, and the supernatant fluid has a deep yellow colour—a sign that sufficient bi-chloride of platinum has been added—the potasso-chloride of platinum is separated by a filter, which has been weighed and dried at a temperature of 100° C. (212° Fahr.), washed with spirits of wine, dried at 100° C. (212° Fahr.) and weighed.

The corresponding quantity of chloride of potassium is calculated from the potasso-chloride of platinum obtained (100 parts of the potasso-chloride of platinum corresponding with 30·51 parts of chloride of potassium). By subtracting this chloride of potassium from the whole sum of the alkaline chlorides, we obtain the quantity of chloride of sodium as the difference.

The quantity of chloride of potassium obtained gives the corresponding quantity of potash when multiplied by 0·6317; and the chloride of sodium multiplied by 0·5302, the corresponding quantity of soda.

B. *Indirect determination of the potash and soda.*—This method of determining the potash and soda is not as accurate as the former. The principle of this indirect method of analysis has been already explained. (Section LXXI., III.) When the total quantity of the chloride of potassium and chloride of sodium has been accurately determined by weighing (as described under A), the saline mass is dissolved in water, the solution poured into a beaker-glass, the cup thoroughly washed with water, and (after the addition of a few drops of neutral chromate of potash-solution) the total quantity of the chlorine determined by a standard silver-solution. (Section LVIII., II.) If we know the total amount of chloride of potassium and chloride of sodium, as well as the total amount of chlorine, the quantity of potash and soda may be thereby determined.

The total quantity of chlorine is multiplied by 2·1029, the sum of the metallic chlorides deducted from the product, and the remainder multiplied by 0·36288. We thus find the quantity of chloride of sodium contained in the saline mass, and this, subtracted from the sum of the metallic chlorides, gives the amount of chloride of potassium.

Chloride of potassium × 0·6317 = potash.
Chloride of sodium × 0·5302 = soda.

SECTION LXXV.

DETERMINATION OF THE CARBONIC ACID IN THE URINE.

According to Marchand (*Journal für Pract. Chemie.*, Bd. 44, p. 253), the free carbonic acid in the urine may be estimated in the following way:—About 100 C. C. of the urine to be tested are put into a glass flask, which is closely fitted with a doubly-perforated cork. Through one opening a tube is passed, which dips into the urine, and which at the other end is drawn out into a fine and readily-fusible point. Through the other opening in the cork a doubly-bent tube is passed, one leg of which is introduced into an empty flask, through a well-fitting cork. This flask is connected by a similar tube with a second flask filled with clear baryta water, which again is connected in a similar way with one or two other flasks half-filled with baryta water—the last of them being connected with an air-pump.

When the apparatus is prepared, the urine is heated in a water-bath to 50° or 60° C. (122° to 140° Fahr.), and the air slowly pumped out. The fluid soon begins to boil and distil over into the empty flask, a cloudiness of carbonate of baryta appearing in the baryta solution. In the course of a half or three-quarters of an hour, the fine extremity of the first tube is broken off, and air drawn through the apparatus. The precipitated carbonate of baryta is then carefully filtered, and, after washing, dissolved in hydrochloric acid, precipitated again by sulphuric acid, and then weighed as sulphate of baryta. From the quantity thus obtained we reckon the amount of carbonic acid in the urine.

SECTION LXXVI.

DETERMINATION OF THE WHOLE OF THE NITROGEN IN THE URINE.

The urine contains nitrogen under several different forms, as in urea, uric acid, creatine, the ammoniacal salts, &c. It is of importance in certain physiological inquiries to be able to ascertain the total quantity of nitrogen passed by the urine with these different compounds. This can only be done by the way of so-called elementary analysis. And here we meet with certain difficulties, inasmuch as the urine cannot be dried without losing some of its nitrogen. These difficulties have been very ingeniously met by Karl Voit, whose method is here described.

A. *Theory.*—All organic nitrogenous bodies which do not contain the nitrogen in the form of nitric acid (and it is with such bodies that we have to deal in the urine), are decomposed when exposed to a red heat, with soda-lime, all their nitrogen passing off in the form of ammonia. The ammonia is readily absorbed by standard sulphuric acid, and may be then determined by volumetrical measurement. 1 equivalent $NH_3 = 17$, corresponding with 1 equivalent $N = 14$.

B. *Preparation of the solutions.*—1. *Standard Sulphuric Acid.*—The sulphuric acid which serves for this purpose must contain about 1 gramme of oil of vitriol in 100 C. C. 12·6 grammes of oil of vitriol are weighed and diluted up to a litre. The quantity of sulphuric acid in each 20 C. C. of this dilute acid is then determined by precipitation with chloride of barium (see Section LXXII., B. 1).

If, for instance, we have ascertained that each 100 C. C. of the acid contains 1·0 gramme of sulphuric acid, then this quantity will correspond with 0·425 gramme of ammonia, or with 0·35 gramme of nitrogen. Consequently, 1 C. C. of the sulphuric acid corresponds with 0·00425 gramme of ammonia, or with 0·0035 gramme of nitrogen.

2. *Standard soda-solution.*—This solution must be of equal value with the sulphuric acid, that is, equal volumes of both must exactly saturate each other. 20 C. C., for example, of the dilute acid, slightly reddened with tincture of litmus, must be exactly neutralised by 20 C. C. of soda-solution, free from carbonic acid, so that, on the addition of the last drop of the 20 C. C. of the soda-solution, the red colour of the sulphuric acid passes into a clear blue. (For the preparation of soda-solutions, see Sections LXXI., B. 2, and LXXII., B. 2.)

C. *The distilling apparatus.*—The neck of a small tubular retort of hard glass, the bulb of which is about 6 centimetres deep, and 3·5 centimetres broad, is bent at a distance of about 10 to 11 centimetres from the bulb, at a right angle, and this part is then drawn out over the lamp into a tube 8 or 9 centimetres long, and of 0·3 centimetre diameter. This part of the neck of the retort, bent at a right angle, is fitted into a cork, which is fixed in a small glass flask capable of holding 130 C. C. The cork has two holes in it. Through one passes the limb of the retort, which must be only raised a few millimetres from the bottom; and in the other hole a glass rod is fixed so as to open above the level of the fluid. The apparatus must be made air-tight; and this may be easily proved by filling the flask with water, and sucking air from the retort through the glass tube. If it be properly closed, the fluid will rise in the neck of the retort, and remain some time at the same level.

D. *Process.*—100 C. C. of the dilute standard sulphuric acid are introduced into the flask; and the bottom of the retort is covered, to the depth of about 1·5 centimetre, with soda-lime, recently heated to redness. The apparatus is then fixed together. 5 C. C. of urine, accurately measured, are poured upon the soda-lime, and the stopper quickly introduced. The soda-lime must be sufficient in quantity to absorb the whole of the urine, so that no fluid remains standing above it. The mixture rapidly becomes warm, and bubbles of gas rise up through the sulphuric acid; when the acid begins to pass back up the neck of the retort, the retort is held by the hand over the gentle flame of Berzelius spirit-lamp. More gas-bubbles are thereby developed, and this is continued until the development of gas becomes strong, when the heat is suspended for a few minutes.

Great care must be taken not to apply too great a heat; the greater part of the water passes off very quickly from the urine, but is deposited in the neck of the retort. And here commences the most difficult part of the operation—the distillation of it over into the sulphuric acid. If the quantity of watery vapour given off is very great, a vacuum may be formed in the retort in consequence of the condensation of the water by the sulphuric acid, and the sulphuric acid thus rush back into the body of the retort. Hence, as soon as this return of the fluid commences, and it invariably occurs, the retort must be quickly brought over the lamp, and strongly heated. In this way the last portion of the water in the mass passes over with a slight frothing of the soda-lime.

When the whole of the water is driven off from the retort, and has been taken up with a loud absorption by the sulphuric acid, the development of the gas proceeds very steadily and regularly. The bottom of the retort, as high up as the soda-lime, should be now surrounded with a close-fitting fine wire-gauze, to prevent any bursting, and exposed to a strong heat. The mixture thereupon first becomes black, and as the fire gets stronger, burns whiter, retaining only a reddish shade.

When the gas-bubbles begin to pass off slowly, care must be taken to prevent the sulphuric acid getting back into the retort. When, therefore, the acid begins to rise, the fire is removed, the glass-stopper taken out of the retort, and air drawn by means of the glass tube through the apparatus. The combustion is now complete; the contents of the flask are washed into a beaker-glass, a few drops of litmus tincture added to them, and the non-saturated portion of the sulphuric acid measured with an equivalent quantity of the soda-solution.

Example.—1 C. C. of sulphuric acid = 0·0035 gramme of nitrogen. The quantity of urine passed in 24 hours, 1200 C. C. In the process 5 C. C. of urine are employed. Of the 100 C. C. of sulphuric acid, 30 C.C. are saturated by volumetrical measurement with the soda-solution.

30 C.C. sulphuric acid = 30 × 0·0035 gramme = 0·1050 gramme nitrogen.

The total quantity of nitrogen passed with the urine in 24 hours:

$$5 : 0{\cdot}1050 :: 1200 : x = 23{\cdot}2 \text{ grammes.}$$

SECTION LXXVII.

Determination of the Fat in the Urine.

Fat is not usually found in the urine, except in very small quantities, and it is only in the most exceptional cases that we have to ascertain its quantity. If such a calculation, however, be required, we must evaporate 20 to 30 C.C. of urine to dryness in a water-bath, and dry the residue thus obtained for a long time in an air-bath, at a temperature of 110° C. (230° Fahr.). To extract the fat from this residue, ether is poured over, and carefully mixed with it, and the mixture, frequently shaken, allowed to digest for some time. The clear ether is then poured off into a light glass tube, which has been weighed; fresh ether is then added to the residue, and the operation repeated so long as anything is taken up by the ether. The ethereal extracts are then evaporated in the glass cylinder, and the residue which remains is calculated as fat.

It must be observed that when the urine contains free lactic acid, the weight of the ethereal extract of the residue will be thereby increased—free lactic acid being itself soluble in ether. It is advisable, therefore, to wash the residue repeatedly with water, until it ceases to take anything up, and then to proceed to the drying and weighing.

THIRD PART.

SYSTEMATIC DESCRIPTION OF THE PROCESSES EMPLOYED IN THE QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE URINE.

SECTION LXXVIII.

I. Qualitative Analysis.

The qualitative analysis of the urine is carried out in two different ways, according as we desire; 1st, to ascertain the absence or the presence of any one particular normal or abnormal constituent of the urine; or, 2ndly, to obtain a complete account of the qualitative constitution of the urine as passed at any given time.

In the first case, a few tests only are required; but, in the second, it is advisable to pursue the plan pointed out as applicable for the analysis of single constituents of the urine.

Such a plan is given in the following section. All the normal constituents of the urine, as well as the most important and most common of its abnormal constituents, are taken into consideration.

With regard to those which are seldom met with, and those which require large quantities of urine for their investigation, the reader is referred to the chapters which treat of them in the First Part of this work. As the special processes requisite for the investigation of all the different constituents of the urine have been already given at length in the First Part of the work, it will only be necessary here to give in a tabular form the operations required; referring to the First Part for the particular methods of carrying them out.

SECTION LXXIX.

A. Process to be followed in the Examination of the Soluble Constituents of the Urine.

1. The reaction of the urine is first tested with litmus paper.

a. If the urine is acid, and contains no sediment, we proceed as described under 2.

b. If the urine is acid, and contains sediment, we allow the sediment to subside, pour off the clear urine, filter if necessary, and then test as described under 2. The sediment is to be examined microscopically. (See Section LXXX.)

c. If the urine is neutral or alkaline, there will generally be a sediment in it; the sediment is to be tested microscopically (Section LXXX.), and the filtered urine as described under 2.

2. A small quantity of the urine, rendered acid (if it is not already so) by a drop of acetic acid, is heated to boiling. If a coagulum is formed, which does not disappear on the addition of nitric acid, it most probably consists of albumen. We now separate, by boiling, the whole of the albumen (Section XIX. C.) from a larger quantity of urine (500 to 600 C. C.), filter, and treat the filtrate as described under 3.

As a confirmatory test, the reaction with nitric acid will serve. (See Section XIX. B. 10). If the quantity of albumen is very small, the nitric acid is carefully covered with a layer of the urine to be tested. In this way a well-defined, ring-shaped cloudiness is produced, even when mere traces of albumen are present. (See Section XIX. E.)

The coagulum thus obtained is either white, greenish, or reddish-brown.

a. If *white*, it consists of pure albumen.

b. If *greenish*, we may suspect that it contains some biliary matters, especially if the urine itself be likewise deeply tinged. (Section XXIV.)

c. If *reddish-brown*, we may suspect the presence of blood in it; and in such case must carefully test the sediment. (Section LXXX.) The dried coagulum is treated with alcohol and a few drops of sulphuric acid. If the fluid, after filtration, has a reddish colour, it is evaporated to dryness and heated to redness; the residue is boiled with water, to which a little hydrochloric acid has been added, and the solution filtered and tested with sulpho-cyanide of potassium. If a red colour appears, the presence of iron is indicated, and shows that blood is probably present in the urine.

Hæmatine in solution is tested by Heller's method. (Section XLIII. B.) A specimen of the urine is heated to boiling, concentrated caustic potash is added, and the colour of the fluid observed, as well as the colour of the earthy phosphates which are separated in thick flocculi, after the fluid has stood at rest for a short time.

3. From 400 to 500 C. C. of clear urine, or of urine from which the sediment or albumen has been separated by filtration, are evaporated in a water-bath to the consistence of a thick syrup, and the residue obtained divided into 2 parts—⅓ and ⅔.

a. The one-third of the residue is extracted with strong alcohol, the undissolved portion allowed to subside, the solution filtered, the residue again washed once or twice with strong spirits of wine, and the solution tested as follows (*aa*); and the residue as described under *c.*

aa. A small quantity of the alcoholic solution is evaporated nearly to dryness in a water-bath, and the residue tested for urea, by adding nitric or oxalic acids. (Section II. D. 9, *a* and *b.*)

bb. The greater part of the alcoholic solution is treated with a few drops of milk of lime, and afterwards with a solution of chloride of calcium as long as any precipitate is thereby thrown down. The filtrate is evaporated in a water-bath to 10 or 12 C. C., introduced into a beaker-glass, and treated when cold with ½ C. C. of an alcoholic solution of chloride of zinc. The mixture, after being well shaken becomes first of all cloudy, and then throws down creatinine-chloride of zinc. The precipitate collected in the course of a few hours is then tested microscopically. (Section III. C. 1.)

b. The two-thirds of the residue are slightly acidulated with hydrochloric acid, rubbed up with powdered sulphate of baryta, and then extracted with alcoholic. The alcoholic solution is employed in testing for hippuric acid, as described in Section VII. E. 1.

The crystals thus obtained are examined microscopically (*Plate I. Fig.* 1), and as far as the materials serve, chemically also. (Section VII. D. 7.)

c. The residue which has been obtained by treatment with alcohol (as described under *a*) is put into a basin with dilute hydrochloric acid (1 part acid and 6 parts water), and the undissolved portion separated by a small filter.

aa. The hydrochloric acid solution contains the earthy phosphates and other salts; the phosphates are precipitated by neutralising the solution with ammonia.

bb. The residue contains mucus and uric acid. After washing it, the filter is perforated, and the residue washed (by a spirt-bottle) into a small test-tube, 2 or 3 drops of soda-solution added to it, and heated, and filtered.

α. The undissolved residue is mucus.

β. The filtrate contains the uric acid, and when treated with hydrochloric acid throws it down in the form of crystals, which are then tested by the microscope. (Section VI. C.) The remainder is dissolved in nitric acid, carefully evaporated to dryness, and subjected to the action of ammonia. (Section VI. E. 1, *a.*) If a purple-violet colour appears uric acid is undoubtedly present.

d. The alcoholic extract of a large quantity of urine is required in testing for lactic acid. (Section XXVI. C.)

4. From 3 to 4 C. C. of fuming hydrochloric acid are mixed in a test-tube with 20 to 24 drops of the urine to be tested. If uroxanthine is present, the mixture will in a short time become of a violet-red, or of an intensely blue colour. If the reaction does not follow on account of the minute quantity of uroxanthine present, it may often be produced by the addition of a few drops of strong nitric acid. (Section IX. 3. C.)

5. If the urine has more or less of a deepish brown or green, &c., colour, if it froths much on being shaken, and imparts a yellowish or greenish tinge to a piece of filtering-paper dipped into it, it should be tested for bile.

a. A small quantity of urine is poured into a conical-shaped glass, and nitric acid containing nitrous acid is dropped into it without shaking. (Section XXIV., B.) If, in the lower part of the fluid a colour arises, which passes through the shades of green, blue, and violet, into red, and finally into yellow, the presence of the brown bile-pigment, cholepyrrhine, is shown.

If there are only mere traces of bile-pigment present, the nitric acid should be carefully covered with a layer of the urine to be tested; or the bile-pigment must be previously separated by means of chloroform. (Section XXIV. B.)

b. A second portion of the urine is precipitated with basic acetate of lead, the precipitate collected on a filter, washed, dried, and treated with alcohol, to which a few drops of sulphuric acid have been added. If the fluid after filtration has more or less of a green tinge, bile-green, biliverdine, is present in it. (Section XXIV. A. *b*.)

c. In testing for bile-acids 300 to 500 C.C. are evaporated in a water-bath, and the alcoholic extract employed. (See the process, Section XXV., *Test*.) Pettenkofer's test is tried, as there explained, in a porcelain basin.

6. To test the urine for sugar:—

a. From 15 to 20 drops of the urine in question are diluted with 4 or 5 C.C. of water, ½ C.C. of caustic soda is added, and a very dilute solution of sulphate of copper then dropped into the mixture. If sugar is present, red suboxide of copper is immediately separated when the mixture is heated, but without heat only after long standing. (Section XXI. D. 1.)

As confirmatory tests we may use:—

α. The potash test. (Section XXI. D. 3.)
β. The bismuth reaction. (Section XXI. D. 2.)
γ. The indigo-reduction test. (Section XXI. C. 7.)
δ. The silver-reduction test. (Section XXI. C. 10.)
ε. The fermentation test. (Section XXI. C. 9.)

b. If the reactions given under *a* are not decisive, if in fact only a trace of sugar is present, we must first of all separate it in a pure form (Section XXI. D. II.), and subject the solution so obtained to the tests here given.

7. If the urine has an odour of rotten eggs, or renders brown or black a piece of paper moistened with acetate of lead (Section XXXI.), the presence of sulphuretted hydrogen is shown.

8. To test the urine for inorganic matters a portion of urine (40 to 50 C.C.) is evaporated to dryness, mixed with 1 to 2 grammes of spongy platinum, and gently heated until the whole of the carbon is driven off. (Section LIII. 2.) The residue is then boiled with water, and the solution filtered and tested as follows:—

a. A little of it is rendered acid with hydrochloric acid, and chloride of barium then added to it. A white powdery precipitate shows the presence of *sulphuric acid*.

b. A second portion is made acid with nitric acid, and a silver-solution added to it. The presence of *chlorine* is shown by the formation of a white curdy precipitate.

c. A third portion is treated with acetate of soda, acetic acid, and a drop of solution of perchloride of iron. The formation of a whitish-yellow gelatinous precipitate shows the presence of *phosphoric acid*.

d. The remainder of the watery solution is evaporated to dryness, nd a portion of the saline mass heated to redness on platinum-foil in he centre of the flame. A yellow colour on the outer part of the oint of the flame indicates the presence of *soda*.

e. The rest of the saline mass (obtained as described under *d*) is issolved in a few drops of water, and chloride of platinum added. The presence of *potash* is shown by a yellow crystalline precipitate.

If the watery extract of the platinum-containing ash of the urine holds in it lime or magnesia, which we may readily learn by testing with phosphate of soda and ammonia, they must be first of all separated by the ordinary analytic process (see Fresenius's *Qualitative Analysis*, 11th Ed.), before we proceed to test for potash and soda. In most cases, however, the watery extract has an alkaline reaction, and does not contain any of the earths.

9. The residue treated with water (see 8) is heated with hydrochloric acid, filtered, washed, and then tested as follows:—

a. A small portion of the solution is boiled with a drop of nitric acid, and sulphocyanide of potassium added to it. The presence of *iron* is shown by the development of a red colour.

b. The rest is treated with an excess of acetate of soda, and tested for *lime* with oxalate of ammonia.

c. All the lime is precipitated, the fluid separated by filtration, and ammonia added to the filtrate. A white crystalline precipitate of ammonio-phosphate of magnesia shows that magnesia is present.

Most of these tests (8 and 9) may be applied to the filtered urine in its original state; but the results necessarily come out much more clearly and distinctly from tests applied to the ash of the urine.

10. In testing for ammoniacal salts, 50 to 100 C. C. of urine are treated with milk of lime in a flask, a piece of moistened turmeric-paper being suspended in it by means of a cork. If ammoniacal salts are present, the paper soon becomes brown. (Section xvii.)

11. The presence of iodine is best shown by distillation of the urine with sulphuric acid. (Section lxvi. c.) The distillate obtained, after separation of the sulphurous acid, may be tested for iodine with a few drops of starch-solution, and careful addition of chlorinated-water, or what is still better, of red fuming nitric acid, instead of using the palladium-solution. (Section lxvi. c.) The smallest quantity of iodine gives rise to the formation of blue iodide of starch.

12. A large quantity of urine is required in testing for phenylic acid, not less than 50 to 60 pounds. (Section VIII.)

13. Acetic and benzoic acids are only found in decomposed alkaline urine. The test cannot be trusted if less than 5 or 6 pounds of urine are employed. Benzoic acid is best obtained from diabetic urine which has undergone fermentation. To separate these compounds we must proceed as described. (Section XXVII. C., and XXIX. D.)

14. Butyric acid is rarely met with in the urine. We must proceed, in testing for it, according to the process described. (Section XXVIII.) Whenever it is possible, several pounds of urine should be employed in the operation.

15. Inosite has hitherto been only found in the urine in cases of morbus Brightii and diabetes. (Section XXIII. D.)

16. For allantoine, see Section XXXII. E.

17. Large quantities of urine are required in testing for xanthine. (Section V. D.)

18. Leucine and tyrosine have been found in the urine in cases of acute atrophy of the liver, in typhus, small-pox, &c. It is probable that urine of this kind also contains valerianic acid. See Section XXXIV. E.

SECTION LXXX.

B. Microscopical Characters of Urinary Sediments.

In testing for urinary sediments, it is necessary to know whether the urine has just been passed, or whether it has stood some time, and is undergoing or has undergone the changes which result from its fermentation. We therefore prove its reaction, allow the sediment to subside completely in a closed glass, pour off the supernatant fluid (which is to be tested according to Section LXXIX.), and then place a drop of the sediment on the object-glass. If the quantity of urine is small, it is allowed to stand in a champagne-glass until it becomes clear, the supernatant fluid is then removed by a pipette, and a drop of the sediment (collected from the pointed bottom of the glass) placed on the object-glass.

If the quantity of urine is large—the 24 hours' urine—it is left at rest in a covered glass, the clear fluid after a time drawn off with a syphon, the remainder poured into a champagne-glass, and the above process then carried out. The drop placed on the object-glass of the microscope is slightly compressed by the covering-glass, and systematically investigated, the whole of it being carefully subjected to inspection. Several drops should be tried, one after the other, and it is advisable to take them from different layers of the sediment, as some kinds of sediment sink more rapidly than others.

When it can be done, two microscopic investigations should be made: firstly, of the urine soon after it has been passed; and, secondly, when it has stood 24 hours. Oxalate of lime, for example, is, generally speaking, not found in freshly-passed urine, appearing only some hours after it has been passed. We should use powers of from 50 to 80 up to from 300 to 400 diameters. If the urine has been filtered in order to separate the sediment, and the sediment then removed by scraping it from the filter, care must be taken that fibres, &c., of the paper are not mistaken for constituents of the sediment.

A. *Acid urine.*—1. *Amorphous sediment,* formed in part of irregular masses, or arranged in branched moss-like rows of exceedingly small granules. A drop of it is heated on the object-glass:

a. If complete solution follows, the presence of *urates* is indicated. When it has cooled, a drop of hydrochloric acid is added, and it is allowed to stand for a-quarter or half-an-hour. If in this time rhombic tables of uric acid are formed, the proof is obtained. *Table I. Fig.* 2.

In most cases sediment of this kind consists of *acid urate of soda,* and is recognised by its reddish colour. *Plate II. Figs.* 1 *&* 2. The sediment is tested chemically as described, Section XXXVII.

With these sediments are very frequently associated crystals of uric acid and of oxalate of lime. *Plate I. Fig.* 3, and *Plate II. Fig.* 4. (See 2.)

b. If the sediment does not dissolve when heated, but dissolves in acetic acid without effervescence, it most probably consists of *phosphate of lime.* We decide its nature by chemical tests. (Section XXXIX.)

c. If we find in the amorphous sediment, minute shining silvery drops, strongly-refractive of light, which dissolve in ether, the presence of *fat* is indicated. (Section XXX.)

[illegible] —a. Small shining, [illegible] in- [illegible] Plate I. Fig. [illegible] than.

[illegible] kind, [illegible] off [illegible] are [illegible] Plate II. Fig. [illegible] We may determine [illegible] Section VI. 2. [illegible] 1.

If we are in doubt as to the nature of some of the crystals, the sediment should be dissolved in a drop of hydrochloric acid on the object-glass, a drop of ammonia then added, and the characters of the crystals which are then formed observed.

At the termination of the acid and at the commencement of the alkaline fermentation the uric acid crystals, which are now more or less coloured, are often seen to be studded with groups of prismatic crystals of urate of soda, upon which again are deposited concentrically arranged groups of urate of ammonia. Not unfrequently solitary crystals of oxalate of lime are also found at this period.

c. Regular six-sided tables, which are soluble both in ammonia and hydrochloric acid, and carbonize and burn when heated, and give a precipitate of black sulphide of lead when boiled with plumbate of potash, consist of *cystine*.

d. Prismatic and often wedge-shaped crystals, which lie some of them separately, and some of them with their pointed extremities so disposed as to form more or less of a circle, consist of *phosphate of lime*. (Section xxxix. 2.) The urine containing them has usually a slight acid reaction.

e. Heavy globular granules of a greenish-brown colour, and with a stellate crystalline structure, may consist of *tyrosine*. A solution of it in ammonia, when saturated with acetic acid, throws down its characteristic groups of long, shining needles. (Section xxxiv. B.)

The different chemical reactions may be employed, if doubts exist. (Section xxxiv. c. 2, 3, 4.)

Urine which contains tyrosine very often also contains bile-pigments.

f. Hippuric acid is very seldom met with as a sediment in the form of needles or of rhombic prisms, which are readily soluble in boiling water. (Section VII. B. D.)

3. *Sediment containing organic bodies.*—*a.* Wound shreds, formed of regularly disposed rows of fine points or granules, consist of coagulated *mucus*, and are often accompanied with urate of soda. *Plate II. Fig.* 2. (Section XLII.)

These must not be confounded with so-called urinary cylinders. See *e.* (Section XLV.)

b. Small, contracted, granular corpuscles, generally united by their borders into overlapping groups, are *mucus-corpuscles.* (Section XLII.) *Plate II. Fig.* 3.

c. Circular, slightly bi-concave discs, with a yellowish tint, which swell out on the addition of acetic acid, and then more or less rapidly dissolve, are *blood-corpuscles. Plate III. Figs.* 1 *&* 2.

Particular attention should be paid to the distended spherical forms, as well as to the angular, jagged, and hacked forms. (Section XLIII.)

When blood is present, the urine contains albumen.

d. Pale, round, indistinctly-granular vesicles of various sizes, which swell out considerably under the action of acetic acid, lose their granular form, and often present nuclei of different forms and groupings, are *pus-cells.* (Section XLIV.) *Plate III. Fig.* 3. These bodies cannot be distinguished from mucus-corpuscles, either chemically or microscopically.

When pus is present the urine contains albumen.

e. Cylindrical-shaped bodies, often studded with blood- and pus-corpuscles, and accompanied with epithelial cells and mucus-corpuscles, are so-called *urinary casts.* (Section XLV.) *Plate I. Figs.* 4, 5, *&* 6.

aa. Cylindrical forms, in which round, nucleated cells are distinctly visible through a fine molecular mass, are the *epithelial cylinders* of the renal tubuli. *Plate I. Fig.* 4.

These forms are usually accompanied with unattached club-shaped, caudate, spindle-shaped, nucleated epithelial cells of the ureters, pelvis and calices of the kidneys. *Plate I. Fig.* 4.

bb. Solid cylinders of a granular character, studded with granules, are the so-called granular kidney cylinders. *Plate I. Fig.* 6.

These cylinders often contain blood- and pus-corpuscles, as well as fat, and fat granules, crystals of oxalate of lime, and single epithelial cells.

This sediment also frequently presents blood- and pus-corpuscles, as well as the free epithelial cells named under *aa*. *Plate I. Fig.* 6.

cc. Solid cylinders, extremely pale and diaphanous, so as to be often with difficulty distinguished from the surrounding fluid, are *hyaline renal cylinders*. *Plate I. Fig.* 5.

These forms assume a yellow colour, and are thereby rendered more distinct on the addition of a solution of iodine in iodide of potassium.

Forms of a character intermediate between *bb* and *cc*, are often met with, the hyaline cylinders being studded with fat, pus-corpuscles, and fine granular masses, having more or less of a granular aspect.

The presence of these different forms should always be sought for in albuminous urine, the magnifying power used being of 180 to 200 diameters.

f. The various forms of *epithelial cells*.

aa. Pavement epithelium. Roundish, longish, or polygonal nucleated cells of the internal and external labia, of the vagina, of the female urethra, the bladder, the pelvis, and calices of the kidneys. *Plate I. Figs.* 4, 5, *&* 6, *Plate II. Fig.* 1.

bb. Cylindrical and egg-shaped epithelium of the under layer of the mucous membrane of the bladder, &c.

cc. Ciliated epithelium of the uterus.

All these forms become distinctly visible under the microscope on the addition of a solution of iodine in iodide of potassium.

g. Fermentation cells and fungi, formed at the commencement of the acid fermentation of urine, accompany sediments of urate of soda, free uric acid, and oxalate of lime, but are met with especially in diabetic urine which has undergone decomposition.

aa. The fermentation fungi consist of small nucleated cells, which increase by gemmation, forming single or double rows. *Plate II. Figs.* 1, 2, *&* 4.

bb. The thready fungi often form a covering so thick as to overshadow the whole field of the microscope.

h. Short delicate bodies, which move twisting about here and there, are *vibriones*, and are very commonly found under a high power in weakly acid or in alkaline urine. (Section XLVII.)

i. *Spermatozoa* are known by their tadpole-like form. (Section XLVI.)

k. Cancer mass. *Plate III. Figs.* 5 *&* 6.

l. The *Sarcina ventriculi* is very seldom met with in the urine. It is readily recognised by its characteristic form. See p. 133, Fig. 3.

B. *Alkaline urine.*—1. *Sediment containing crystals.*—Combinations of vertical rhombic prisms, which are soluble in acetic acid, and develope ammonia when heated with caustic soda, are crystals of *ammonio-phosphate of magnesia.* (Section XXXIX. 1.) *Plate II. Figs.* 3 *&* 5.

If *oxalate of lime* should be mingled with these, the sediment is to be treated with a drop of acetic acid under the microscope; the crystals of the magnesian-phosphate are dissolved, and oxalate of lime, in its letter-cover form of crystal, remains.

b. Roundish opaque masses, studded like a thorn-apple with peculiar fine points, and glandular conglomerates, consisting of small, curved, club-shaped bodies, consist of *urate of ammonia.* (Section XXXVII. 2. *Plate II. Fig.* 5.)

2. *Sediment containing amorphous masses.*—These masses, when found in alkaline urine, usually consist of *phosphate of lime.* (Section XXXIX. 2.)

3. *Sediment containing organised bodies.*—In addition to *mucus-*, *blood-*, and *pus-corpuscles*, &c., we also find in such urine *fermentation globules* and thready *fungi*, *infusoria* and *confervæ.* (Section XLVII.) Page 133, Fig. 2.

SECTION LXXXI.

MODE OF PRESERVING URINARY SEDIMENTS.

As it is often desirable to preserve urinary sediments, as microscopical objects, the following short account of the process necessary is here introduced. The most important point is to separate the sediment from the urinary fluid, as the urine readily undergoes decomposition, and organised bodies rapidly form in it. The sediment, therefore, is allowed to deposit in a champagne-glass the urine removed with a syphon, and the sediment washed three or four times by decantation with that particular fluid, which is afterwards used in making the preparation.

Two methods may be adopted: either the washed sediment is introduced into a very small tube, which is then filled with the preparation-fluid, the nature of its contents being marked on it; or the sediment is placed upon an object-glass, and preserved under the cover-glass, the air being excluded.

Of the different preparation-fluids applicable for this purpose, we may mention glycerine-solution,* creosote, pyroxilic spirit-solution,† and dilute rectified spirit.‡ These different fluids serve best for the preparation of the various kinds of epithelia, urinary casts, pus, and mucus-corpuscles, fungiform bodies, uric acid, urates, oxalate of lime, &c.

Ammonio-phosphate of magnesia is best preserved in water to which a little ammonia has been added. Very dilute acetic acid is used for cystine. Crystalline sediments may be preserved in Canada balsam, after they have been well washed and thoroughly dried. The following is the simplest way of proceeding: the washed sediment is placed on the object-glass, and dried in the sun or over sulphuric acid; it is then moistened with a drop of oil of turpentine, the greater part of which is allowed to evaporate. A drop of Canada balsam is now placed upon it, it is gently warmed, any air-bubbles present removed with a needle, and covered with a glass previously warmed. By careful pressure, any excess of balsam is forced out, and in the course of a few days it dries up and closes the border of the preparation. For greater security, the border may be smeared with asphalt varnish, an article of commerce, and readily applied with a camel's-hair brush.

For preservation of the sediment in a fluid, we proceed as follows: a drop of the sediment, suspended in the preparation-fluid, is placed

* Glycerine-solution is obtained by diluting commercial syrupy glycerine with an equal quantity of camphor-water. It forms a most excellent preparation-fluid.

† Creosote and pyroxilic spirit-solution is obtained in the following way: —Three drachms of creosote are mixed in a mortar with six ounces of precipitated chalk, and lime added, until the whole is converted into a soft mass, which is then rubbed up with 64 ounces of water. A few pieces of camphor may also be added. The mixture is then allowed to remain for two or three weeks in a lightly-covered glass, being frequently stirred up; the clear fluid is then poured off, and, after filtration, is preserved in a well-closed glass.

‡ Rectified spirit is diluted with two to eight times its quantity of water. It is not well adapted for microscopic preparations, as it is difficult to obtain, when using rectified spirit, a perfectly air-tight preparation.

on the object-glass, and the glass-cover, previously moistened with the breath, slipped over it by the aid of the forceps, care being taken that no air is enclosed with it. Any excess of the fluid is removed by gentle pressure, and carefully taken up by means of filtering paper. The preparation is then laid aside for some minutes in order to allow the rest of the fluid to evaporate. We now place the preparation under the microscope to see that the whole is in order, and then proceed to render it air-tight. The glass-cover is first fixed to the object-glass by means of wax. The wick of a thin wax-taper is cut into the shape of a chisel, warmed over a spirit-lamp until the wax melts; but it is not allowed to flame. This wick is then held horizontally, and passed quickly around the edge of the preparation. Drops of wax must not be allowed to fall, and in fact only enough of it left around the border of the preparation to fill up completely the furrow between the object and the cover-glasses. The whole of the border of wax must not be more than 2 millimetres broad. With a little practice, the wax may be laid on as smoothly as fluid with a brush.

When the layer of wax is complete, it is covered with asphalt varnish, which may easily be laid on with a hair-pencil, so that, in addition to the wax, it covers both glasses to the extent of 2 millimetres. The whole preparation will thus be about 6 millimetres broad. In applying the asphalt varnish, care should be taken that all the borders are well covered, and that no air-bubble is anywhere enclosed —satisfying ourselves on this point by means of a lens. Especial care should also be taken not to make this first layer of varnish too thick, for in such case it hardens only on the surface, and the deeper parts of it remain fluid, and thus spoil the preparation. I have lost many preparations in this way. If, after 24 hours, the layer of varnish has become solid, a second, thicker one, is then laid upon it; and the preparation may then be ticketed.

The object-glass should be 48 mm. long, and 28 mm. broad. On both ends of it, to the extent of 10 mm., some kind of covering should be stuck with a solution of gum or silicate of potash varnish, and on this covering the ticket is to be fixed. This protective sort of covering is very necessary, for when it is used the preparations may be packed one on the other without endangering the cover-glass. The preparations thus perfected should never be placed on their edges, for in this position they are liable to spoil; they should always be laid flat in the box, which also should be lined with cloth. The process here described is applicable not only to urinary sediments, but also to other microscopic preparations. Complete instruction on this head may be found in Welker's *Aufbewahrung microscopischer Objecte*, Giessen, 1856, as well as in Reinhard's *Das Microscop und sein Gebrauch für den Arzt*, Leipzig and Heidelberg, 1857; *Medicinische Hand-Bibliothek*, Bd. VII.

SECTION LXXXII.

II. QUANTITATIVE ANALYSIS OF THE URINE.

Having obtained a satisfactory knowledge of the qualitative constitution of the urine according to the process described (Sections LXXIX. and LXXX.), we proceed to the quantitative analysis of its constituents. Unfortunately we do not possess plain and certain methods for determining the quantity of the whole of the constituents of the urine, and must therefore be satisfied with a knowledge of the most important of its normal and abnormal constituents.

1. *Quantity of urine passed in a given time.* (Section L.)

The quantity of urine, according to the object desired, is determined either for 24 hours or for a shorter time. For determining the quantity in cubic centimetres, see Section L.

2. *Specific gravity of the urine.* (Section LI.)

In most cases, the specific gravity of the urine can be determined with the urinometer (Section LI. 1.). But if great exactitude is required, the specific gravity must be obtained by weighing the urine. (Section LI. 2.).

The temperature of the urine must of course be taken at the same time as its specific gravity.

3. *The quantity of the water and of the soluble constituents of the urine.* (Section LII.)

10 to 15 C.C. of urine, in a porcelain basin of known weight, are

evaporated in a water-bath, as described in Section LII., and the residue dried in an air-bath at 100° C. (212° Fahr.), until it ceases to lose in weight. By subtracting the weight of the basin, we obtain the amount of soluble bodies in the urine, and by subtracting these from the whole weight of the urine employed, we obtain the quantity of water in the urine. Much more accurate results are obtained when the evaporation of the urine is effected in the apparatus described in Section LII. Fig. 12. The ammonia which is liberated during the evaporation of the urine, through the decomposition of the urea, is calculated for urea, and added to the residue obtained by weighing. (Section LII. 2.)

4. *Inorganic salts of the urine.* (Section LIII.)

The residue obtained by the process 3 is mixed with 1 to 2 grammes of accurately-weighed spongy platinum, and gently heated until the organic parts are completely burnt off, and the residue has assumed a clear grey colour. (Section LIII. 2.) The quantity of inorganic salts is obtained by subtracting the weight of the crucible and the platinum.

If we wish to determine separately the constituents which are soluble and insoluble in water, we heat the residue containing the platinum with water to boiling, filter, wash, and evaporate the watery extract to dryness, heat to redness and weigh. The weight (as obtained) of the salts soluble in water subtracted from the total quantity of the inorganic constituents gives, as the difference, the quantity of salts insoluble in water.

5. *Determination of the colouring-matter according to Vogel.*

The process is carried out as described in Section LIV.

6. *Determination of the chlorine and urea:*

A. *When the urine contains no albumen.* 50 C. C. of urine are mixed with 25 C. C. of a cold saturated solution of caustic baryta and nitrate of baryta (Section LVIII. B. 4), and the precipitate separated by filtration through an unmoistened filter.

The filtrate obtained is divided into two portions.

a. One portion is slightly acidulated with dilute nitric acid, 15 C. C., corresponding with 10 C. C. of urine, are measured off with the pipette, and treated with a standard solution of nitrate of mercury, dropped out of Mohr's pipette, until a permanent whitish cloudiness appears in it. Every cubic centimetre of the mercury-solution used corresponds with 10 milligrammes of chloride of sodium, or with 6·065 milligrammes of chlorine. For the preparation of solutions, &c., see Section LVIII.

b. The second portion of the filtrate is not made acid, but 15 C.C. = 10 C.C. of urine, are measured off with the pipette, and the quantity of urea determined by a standard solution of nitrate of mercury. (Section LX.) This is added out of a pipette until a drop of the mixture, when saturated with carbonate of soda on a watch-glass, gives a distinct yellow colour. If the mixture remains white, some of the urea still exists uncombined, and more of the mercury-solution must be added.

The results of the first experiment should be controlled by a second one. Each cubic centimetre of mercury-solution employed corresponds with 10 milligrammes of urea. For preparation of the solutions, &c., see Section LX.

Corrections.—aa. Urine containing more than 2 *per cent. of urea.*

If more than 30 C. C. of the mercury-solution have been employed for the 15 C. C. of the urine-mixture, we must add a quantity of water equal to half that quantity of the mercury-solution, which has been used in excess of the 30 C. C., before treating the mixture with carbonate of soda. (Section LX. D. 1.)

bb. Urine containing less than 2 *per cent. of urea.*

If less than 30 C. C. of the mercury-solution have been employed for the 15 C. C. of the urine-mixture, we must subtract for every 5 C. C. less than the 30 C. C. which have been used, 0·1 C. C., and then calculate the remainder for urea. (Section LX. D. 2.)

cc. Urine containing from 1 *to* 1½ *per cent. of chloride of sodium.*

a. We must subtract 2 from the number of cubic centimetres of mercury-solution employed, and calculate the remainder for urea. (Section LX. D. 3.)

b. If absolutely correct results are required, the chlorine must be first of all separated by a standard solution of nitrate of silver. We then determine the quantity of urea in the filtrate, in the ordinary way, with the mercury-solution, making allowance as usual for the dilution (*bb*) which has been caused by the silver-solution. (Section LX. D. 3.)

dd. Urine containing carbonate of ammonia. (Section LX., D. 5, *b.*)

A measured volume of urine which has been completely precipitated by baryta-solution (Section LX. D.), is subjected to distillation, and the ammonia which is set free received in a measured volume of standard sulphuric acid. (Section LX., D. 5, *b*.) Every cubic centimetre of the saturated acid corresponds with 11·32 milligrammes of ammonia, or with 20 milligrammes of urea.

In the residue, freed from ammonia, the quantity of undecomposed urea is determined in the ordinary way.

B. *Urine containing albumen.* — The albumen contained in a certain quantity of urine is coagulated (Section LX. D. 4), and filtered, and the chloride of sodium and the urea determined in the usual way, after precipitation of the phosphoric acid by baryta-solution. (Section LX. D. 4.)

7. *Determination of the phosphoric acid.* (Section LXI.)

a. Determination of the whole amount of it.—50 C.C. of urine are treated with 5 C.C. of a solution of bi-acetate of soda, heated in a water-bath, and the phosphoric acid measured with a standard solution of acetate of uranic oxide. The mixture must be frequently tested while the solution is being added, a drop of it being treated with ferrocyanide of potassium-solution, as already described. (Section LXI. C.) When a slightly-red colour appears, we know that there is just a trace of excess of uranic-oxide in the mixture, and therefore, that enough of the solution has been added.

Every cubic centimetre of the solution of uranic oxide which has been used corresponds with 5 milligrammes of phosphoric acid. (Section LXI. C. *a*.)

b. Phosphoric acid in combination with alkalies.—50 C.C. of urine are rendered alkaline with ammonia; the earthy phosphates, in the course of a few hours, removed by filtration, the precipitate washed, and the quantity of phosphoric acid determined (see *a*) in the whole of the filtrate after the addition of 5 C.C. of the acetate of soda-solution.

Every cubic centimetre of uranic oxide-solution employed indicates 5 milligrammes of phosphoric acid combined with alkalies. The quantity thus obtained subtracted from the total amount previously determined gives, as the difference, the quantity of phosphoric acid combined with the earths.

8. *Quantity of free acids in the urine.* (Section LXIII.)

A solution of caustic soda graduated with pure oxalic acid is dropped into 50 C.C. of urine, until the urine loses its acid reaction, and a drop of it on litmus-paper, neither turns the blue red, nor the red blue. Each C. C. of soda-solution used corresponds with 10 milligrammes of oxalic acid.

9. *Determination of the sulphuric acid.* (Section LXIV.)

100 C. C. of urine are heated to boiling after the addition of 20 to 30 drops of hydrochloric acid, and a standard solution of chloride of barium, each cubic centimetre of which indicates 10 milligrammes of sulphuric acid, is dropped into it, until an excess of the baryta is shown to exist, when a little of the filtered mixture is tested with sulphate of potash. If we have up to this point used 12 C. C., and if no reaction takes place when only 11 C. C. have been used, we are sure that the true quantity lies between 11 and 12 C. C. We therefore at once add to a fresh quantity 11 C. C. of the chloride of barium-solution, heat it to boiling, and then carry out the process to the end. (Section LXIV. c.)

10. *Determination of the sugar.* (Section LXV.)

The urine must be diluted so as not to contain more than ½ per cent. of sugar at most. 10 C. C. of the standard copper-solution are therefore measured off, and diluted with 40 C. C. of water, and then added to the diluted urine, until the whole of the copper is reduced, and until a little of the mixture, made acid with hydrochloric acid, and tested with sulphuretted hydrogen, ceases to become cloudy. In most cases a proper dilution of the urine is obtained by mixing 5 C. C. of diabetic urine with 95 C. C. of water. The dilution, however, must depend upon the quantity of sugar in the urine.

The volume of urine employed for the complete reduction of the copper contains exactly 50 milligrammes of diabetic sugar. If, therefore, we have diluted the urine with 20 times its volume of water before testing, we must divide 20 × 5 = 100 by the number of cubic centimetres employed, in order to obtain the percentage of sugar in the urine. (Section LXV. c.)

11. *Determination of the albumen.* (Section LXX.)

The process described in Section LXX. must be followed out.

12. *Determination of the uric acid.* (Section LXVIII.)

a. Precipitation with hydrochloric acid.—200 C. C. of urine are treated with 5 C. C. of hydrochloric acid, of sp. gr. 1·11, covered and left at rest for 24 to 36 hours at a temperature of 10° to 20° C. (50° to 68° Fahr.) in a cellar. In most cases 24 hours are long enough. The fluid is then removed with a pipette, and the crystals collected on a small, dried, and previously weighed filter. After washing—the water dropping away should not have an acid reaction —the crystals are dried at 100° C. (212° Fahr.), and weighed. (Section LXVIII. A.)

If the urine should be much diluted, or contain very little uric acid, 200 C. C. should be evaporated to 50 C. C. before the addition of the hydrochloric acid.

The washing-water and the filtrate are then accurately measured, and for every 26 C. C. at 10° C. (50° Fahr.), or for every 17·5 C. C. at 20° C. (68° Fahr.), 1 milligramme of uric acid must be calculated as remaining in solution. The quantity thus obtained must be added to the quantity as directly obtained.

b. Determination of the uric acid in the residue of urine.

20 C. C. of urine are evaporated to a syrup in a water-bath, extracted with alcohol, and the remainder treated with dilute hydrochloric acid; the uric acid is then separated by filtration through a dry filter whose weight is known, washed, dried at 100° C. (212° Fahr.), and weighed. (Section LXVIII. B.) (I much prefer the former process.)

c. For the modification required by the presence of albumen, see Section LXVIII. C.

13. *Determination of the creatinine in the urine.*

The process described in Section LXIX. C. must be followed.

14. *Determination of the lime in the urine.*

200 C. C. of urine are treated with ammonia, the precipitate which forms dissolved in as small a quantity as possible of acetic acid, and the lime precipitated with oxalate of ammonia. When the fluid has become perfectly clear, it is removed by a pipette, the oxalate of lime collected on a filter, washed, heated to redness, and graduated with hydrochloric acid and caustic soda, as described. (Section LXXI. C.). 1 C. C. of saturated hydrochloric acid corresponds with 10 milligrammes of lime, or with 18·49 milligrammes of tribasic phosphate.

15. *Determination of the magnesia in the urine.*

a. The fluid, as obtained above (14), is mixed with the washing-water, and the magnesia precipitated by ammonia as ammonio-phosphate of magnesia. After 12 hours the clear fluid is drawn off by a pipette, the precipitate collected on a filter, washed, heated to redness, and weighed. (Section LXXI. II. 1.) Or the ammonio-phosphate of magnesia may be dissolved in acetic acid, and the quantity of magnesia determined by the graduated measurement of the phosphoric acid contained in the precipitate. (Section LXXI. II. 3.)

b. 200 C. C. of urine are precipitated with ammonia; after some hours the earthy phosphates which separate are collected on a filter, washed, and heated to redness. (Section LXXI. II. 2.) The quantity of phosphate of lime obtained, subtracted from the quantity of earthy phosphates thus collected, gives, as a remainder, the quantity of phosphate of magnesia ($2MgO, PO_5$) present in the urine. I prefer this process to the one decribed under *a.*

16. *Determination of the ammonia in the urine.*

20 C. C. of urine are mixed with milk of lime in the apparatus described and figured in Section LXXII. C., and brought under the influence of a measured volume of standard sulphuric acid; the non-saturated portion of the acid is (after 48 hours) graduated with caustic soda of known strength. (Section LXXII. C.)

17. *Determination of the iron in the urine.*

200 C. C. of urine are evaporated to dryness, heated until all the carbon is burnt off, and dissolved in hydrochloric acid; the oxide of iron formed is then reduced by boiling with sulphite of soda, the mixture allowed to cool, and diluted to 60 C. C. The quantity of iron present is determined by a solution of permanganate of potash, whose strength has been ascertained (immediately before using it) by a solution of oxalic acid or ferrocyanide of potassium. (Section LXVII.)

18. *Determination of potash and soda.* (See Section LXXIV.)

19. *Determination of the fat.* (See Section LXXVII.)

20. *Determination of the free carbonic acid.* (See Section LXXV.)

21. *Determination of the iodine.* (See Section LXVI.)

22. *Determination of the total quantity of nitrogen in the urine.* (See Section LXXVI.)

SECTION LXXXIII.

III. PRACTICAL DIRECTIONS FOR ESTIMATING APPROXIMATIVELY THE QUANTITY OF THE DIFFERENT CONSTITUENTS PRESENT IN THE URINE.

Although we are enabled by means of volumetrical analysis to ascertain very quickly, and with certainty, the quantity of most of the constituents of the urine, still cases occur in which the physician desires to know at once whether the urine contains more or less of a particular constituent than it does at another time.

It is not necessary to give special directions for the approximative estimation of every one of the constituents of the urine. The two processes employed by Beneke will serve as examples in other cases. (Beneke: "*Zur Physiologie und Pathologie des phosphorsauren und oxalsauren Kalks,*" Göttingen, 1850.)

1. *Estimation of the quantity of earthy phosphates* (after Beneke).—The earthy phosphates are held in solution in the urine by its free acid, and separated from it, when the urine becomes alkaline. Hence when the free acid of the urine is saturated by an alkali, a precipitate will form, if the urine contains any earthy phosphates. And according to the amount of earthy phosphates there will be either a very slight cloudiness, or none at all, or there will be a more or less well-marked precipitate, the variations in this respect being sufficiently characteristic to enable us to form an approximative idea of the quantity present in the urine.

If we always employ a glass of the same diameter, and which contains at a certain mark exactly 15 to 20 C. C., we may, as Beneke's numerous experiments show, distinguish between many different degrees of cloudiness or precipitation. If we, in the first place, establish a scale for the different degrees of cloudiness which arise, and, secondly, measure by accurate analysis the actual quantity which corresponds with each degree of the scale, we obtain the conditions requisite for the performance of the experiment.

Seven different degrees of cloudiness are given by Beneke for the calculation of the earthy phosphates, the exact quantity corresponding with each of which he ascertains by the method described in Section LXXI.

Beneke marks :—

1. With 0, urine, in which on being boiled in a test-tube, and

after the addition of 10 to 15 drops of a soda-solution (1 part of soda in 12 parts of water), no turbidity is perceptible, but which remains as clear as it was originally;

2. With ½, urine, which when similarly treated yields a slight opalescence;

3. With 1, urine, which when similarly treated yields a strong opalescence, yet of such a kind that objects, as the borders and frame of a window, may be distinguished through it;

4. With 1½, urine, which on addition of the soda-solution yields a turbidity so strong, yet still of an opalescent nature, that objects can be scarcely at all distinguished through it;

5. With 2, urine, which becomes very turbid, and loses its opalescence;

6. With 2½, urine, which in the course of a few seconds after the addition of the soda, yields a considerable precipitate of earthy phosphates;

7. With 3, urine, which immediately forms a large precipitate;

8. With 3 to 4, urine, which separates a very large quantity of earthy phosphates immediately after the addition of the soda.

It is easy to see, that by frequent repetition of experiments of this kind, a person may soon accustom his eye to the different degrees of turbidity, so as to be able readily to assign their true place in the scale. Cases however occur, in which the appearances do not agree with those of any one of the numbers given; such cases may be accurately enough marked as ¼, ¾, 1¼, 1⅓, &c.

If the urine is alkaline, we must share it equally with the sediment present in it, then boil one part, and according as the alkaline reaction is weak or strong, add little of the soda-solution or none at all. But if the urine contain albumen, this must be coagulated by boiling, the urine filtered, and the filtrate then tested for phosphates.

Beneke finds, after careful analysis, that his scale as above given represents the following quantities in one ounce of urine:—

Urine marked	0	contains from	0·100 to 0·150	gramme of earthy phosphates.
„	½	„	0·250 to 0·300	„
„	1	„	0·400 to 0·450	„
„	1½	„	0·550 to 0·600	„
„	2	„	0·700 to 0·750	„
„	2½	„	0·850 to 0·900	„

marked 3 contains from 1·000 to 1·050 gramme of earthy phosphates.

„ 3 to 4 „ 1·000 to 1·300 „

this means we may readily reckon, and with tolerable ac-y, the amount of earthy phosphates passed with the urine in ours.

Estimation of the quantity of oxalate of lime (after Beneke).—obtaining an approximative idea of the quantity of oxalate of in the urine, Beneke makes use of a method similar to that just ibed. It may be thus shortly explained: In testing urine for te of lime, it is necessary on each occasion to allow a portion of rine to remain at rest in the test-glass for 24 hours. If, at the f this time, a sediment has collected in the lower end of the the clear fluid is poured off, and one of the last drops of it ined under the microscope; this must not be omitted, even if istinct cloudiness be observed in the urine tested. If we find sediment of urates, the drop is gently heated on the object- and the urates thus dissolved; phosphate of lime sediment, if nt, is removed by a drop of acetic acid; so that the oxalate of alone will in most cases be left.

operating in this way, and by always using only a single drop urine which contains the sediment, taking care also to cover rop with a thin glass cover, we shall be able to decide as to the ity of oxalate of lime present in the urine.

neke has given a table of the different quantities of lime:—

Urine marked	0	contains	no oxalate of lime.
„	½	„	very little.
„	1	„	little.
„	1½	„	a moderately large quantity.
„	2	„	a tolerably large quantity.
„	2½	„	much.
„	3	„	very much.
„	3 to 4	„	an exceedingly large quantity.

ery one can, of course, make tabular scales of this kind for lf. I shall therefore content myself with merely giving these ods of Beneke. Similar tables can be made for estimating the ien, uric acid, sulphuric acid, &c.

ANALYTICAL PROOFS.

I. *Table for estimating from its specific gravity the quantit matters dissolved in the urine.*

Specific Gravity.	As found by Weighing.	Calculated by 0·233.
	per 1000.	per 1,000.
1·0160	37· 4	37·28
1·0260	62· 0	60·58
1·0154	35· 1	35·88
1·0261	60· 2	60·81
1·0213	48· 6	49·63
1·0230	56· 4	53·59
1·0230	56· 0	53·59
1·0225	49· 3	52·42
1·0240	54· 1	55·92
1·0257	60· 4	59·88
1·0275	63· 9	64·07
1·0275	64· 2	64·07
1·0217	48· 5	50·56
1·0223	52·15	51·96
1·0140	31·08	32·62
1·0236	56·64	54·98
1·0133	30·87	30·99
1·0134	31·06	31·22
1·0238	57·09	55·45
1·0250	60·47	58·25
1·0164	37·26	38·21
1·0135	33·35	31·45
1·0210	48·54	48·93
1·0137	32·55	31·92
1·0085	19·16	19·80
1·0110	24·96	25·63
	Mean.	
1·0200	46·59	46·52

From these data we find that by division of the three last deci of the mean specific gravity, into the mean quantity of solid mat found in 1000 grammes of urine, we obtain the quotient 0·232 which we may, as Häser suggests, conveniently put down as 0·2 By multiplying with this quotient the three last of the 4 decimal the specific gravity, we obtain the number given in the t column, whose difference from the quantity as obtained by weigh seen in the second column. If the specific gravity is only gi with three decimal figures, the 2nd and 3rd decimals multiplied by 2·33 will still yield an approximative estimation of the quantity of solid matters in 1000 parts of urine.

II. *Determination of the chlorine.* (Section LVIII.)

The comparative analyses are conducted in the following order:—

A. *Liebig's method* with a standard solution of proto-nitrate of mercury. (Section LVIII.)

B. *Mohr's method* with a standard solution of nitrate of silver in neutral urine, with addition of chromate of potash. (Section LVIII. II.)

C. *Analysis with a standard solution of silver,* the urine having been precipitated with baryta-solution, and acidified with nitric acid. (Section LVIII. II.)

D. *Analysis by weight.* The urine acidified with nitric acid is precipitated with nitrate of silver. The precipitate is washed, dried with fused carbonate of soda-potash, the mass treated with boiling water, the solution filtered, acidified with nitric acid, and then for a second time precipitated with the silver-solution. The chloride of silver thus obtained is weighed, according to the ordinary method, in a half-fused state.

E. The urine is accurately precipitated, as in D, with nitrate of silver, the precipitate reduced by heating it with soda-potash, the mass treated with water, and the filtrate accurately neutralised with nitric acid. The quantity of chlorine in this solution is then determined by Mohr's method with a standard solution of silver, with addition of chromate of potash.

The following table shows the results obtained by these different methods:—

10 C. C. of urine gave of chloride of sodium:—

A.	B.	C.	D.	E.	
I. 0·153	0·174	—	0·155 0·154	—	(Kerner.)
II. 0·1346	0·158	—	0·137	—	
III. 0·0904	0·106	—	0·0909 0·0902	0·0905 0·0905	
IV. 0·0721	0·0877	0·0742	—	0·0719 0·0720	

It appears from this table, that, when carefully carried out, Liebig's method (A) comes nearest to the analysis by weight. The next is the process with the graduated solution of silver, the urine having been previously precipitated with baryta-solution (C). The method E gives very accurate results. The results of Mohr's method, B, agree least of all with the analysis by weight. The cause of these differences has been explained. (Section LVIII.)

III. *Determination of the phosphoric acid.* (Section LXI.)

A. With uranic-oxide solution. (Section LXI.)

The volumetrical analysis was performed according to the method previously described for every 50 C. C.; and the estimation by weight for every 100 C. C. according to the ordinary method, and with due regard to all requisite precautions. The ammonio-phosphate of magnesia, before it is subjected to a red-heat, was moistened with nitrate of ammonia, to render the pyrophosphate of magnesia perfectly white.

The following were the results obtained:—

	Volumetrical Analysis.	Analysis by weight.
100 C. C.	0·1302	0·1303 0·1299
100 C. C.	0·2352	0·2342
100 C. C.	0·13899	0·1383 0·1410?
100 C. C.	0.1312	0·1318 0·1324

B. With perchloride of iron solution. (Section LXII.)

For the accurate determination of the quantity of iron in the perchloride of iron-solution, every 10 C. C. of it are precipitated with ammonia, &c.

We thus obtain:

a. 0·1125 gramme $\left.\begin{matrix} \\ \\ \end{matrix}\right\}$ Fe_2O_3.
b. 0·1141 gramme

In 10 C. C. a mean of 0·1133 gramme Fe_2O_3 = 0·07931 gramme Fe.

Then, again, a solution of phosphate of soda was employed, containing 0·1185 gramme of phosphoric acid in 10 C. C.

If to 10 C. C. of this solution (no further diluted), after the addition of 10 C. C. of acetate of soda-solution, 11·5 C. C. of perchloride of iron-solution are employed, and the precipitate corresponds with the composition Fe_2O_3, PO_5,—then

$$\frac{\text{1 Equiv. } Fe_2O_3}{80} : \frac{\text{1 Equiv. } PO_5}{71{\cdot}36} :: \frac{Fe_2O_3 \text{ in 11·5 C. C. of solution.}}{0{\cdot}130295 : x}$$

$$x = 0{\cdot}1163 \text{ gramme } PO_5.$$

To bring a phosphoric acid solution to the same degree of dilution as the urine, 10 C. C. of the above solution of phosphate of soda are treated with 50 C. C. of water, and 10 C. C. of acetate of soda-solution.

Of this to the moment of the beginning of the reaction:—

12 C. C. of perchloride of iron-solution
12·3 C. C. " "
12·5 C. C. " "

have been employed; and up to the time when a very distinct, and tolerably deep-blue colour appears:—

12·7 C. C. of perchloride of iron-solution,
13·3 C. C. " "
13·5 C. C. " "

In this dilution also, in order to arrive at the very commencement of the reaction, an excess—more than 1 equiv. of Fe_2O_3 to 1 equiv. of PO_5—must be added:—

a. 0·3 C. C. Fe_2Cl_3 solution; corresponding with 0·003399 grm. Fe_2O_3.
b. 0·6 C. C. " ; " " 0·006798 " "
c. 0·8 C. C. " ; " " 0·009064 " "

Consequently too much phosphoric acid was obtained:—

a. $PO_5 = 0{\cdot}00303$ gramme.
b. $PO_5 = 0{\cdot}00606$ "
c. $PO_5 = 0{\cdot}00808$ "

To produce a distinct deep blue reaction, the following excess must be added:—

a. 1 C. C. Fe_2Cl_3 solution; corresponding with 0·01133 gramme $Fe_2O_3 = 0{\cdot}01011$ gramme PO_5.
b. 1·6 C. C. Fe_2Cl_3 solution; corresponding with 0·01873 gramme $Fe_2O_3 = 0{\cdot}01671$ gramme PO_5.
c. 1·8 C. C. Fe_2Cl_3 solution; corresponding with 0·02039 gramme $Fe_2O_3 = 0{\cdot}01818$ gramme PO_5.

As an average, therefore, an excess of 1·5 C. C. of the perchloride of iron-solution must be added to 50 C. C. of phosphoric acid solution, diluted to the same extent or thereabouts as the urine. The error is also discovered when we use the perchloride of iron solution, prepared after Breed's formula, 10 to 15 milligrammes of PO_5 being found in excess in 50 C.C. of urine. If, however, we employ a perchloride of iron solution, whose strength has been determined by a trial with a phosphoric acid-solution, diluted to about the same strength as the urine, the error becomes very small.

These investigations were conducted at my desire, by my friend Herr Remy.

IV. *Determination of the sulphuric acid.* (Section LXIV.)

The sulphuric acid was determined, in the one case, by weighing in every 100 C. C. of urine; and in the other, by graduated measurement up to the neutral point. The following are the results obtained:—

By weighing.	By volumetrical analysis.
0·129 gramme SO_3.	0·128 gramme SO_3.
0·182 „ „	0·177 „ „
0·274 „ „	0·270 „ „
0·139 „ „	0·137 „ „
0·235 „ „	0·238 „ „

V. *Determination of the sugar.* (Section LXV.)

0·4 gramme of pure grape-sugar was dissolved in 20 C.C. of urine, and diluted up to 100 C. C.; consequently the urine contained 2 per cent. of sugar. 12·3 C. C. of it were employed in the reduction of 10 C.C. of copper-solution. Hence we have

$$\frac{5 \times 5}{12{\cdot}3} = 2{\cdot}03 \text{ per cent.}$$

0·6 gramme of grape-sugar were dissolved in 20 C. C. of urine, and diluted up to 100 C.C.; consequently the urine contained 3 per cent. of sugar. 8·4 C.C. of it were employed in the reduction of 10 C.C. of the copper-solution. Hence we have

$$\frac{5 \times 5}{8{\cdot}4} = 2{\cdot}97 \text{ per cent.}$$

2 grammes of grape-sugar were dissolved in 20 C. C. of urine, and diluted up to 400 C.C.; the urine, consequently, contained 10 per cent. of sugar. 10·5 C. C. of it were required for the reduction of 10 C. C. of the copper-solution. Hence

$$\frac{20 \times 5}{10{\cdot}5} = 9{\cdot}5 \text{ per cent.}$$

VI. *Determination of the uric acid.* (Section LXVIII.)

Every 200 C. C. of a uric acid solution of known strength were precipitated with 5 C. C. of hydrochloric acid, of 1·11 sp. gr., at a temperature of 10° to 12° C. (50° to 54° Fahr.). About 7 to 10 per cent. of uric acid were found wanting—the uric acid remaining in solution. As an average of 10 experiments, which were conducted at the same temperature, and with a similar amount of acid contents, it appeared, on measurement of the filtrate and of the washing water, that about one milligramme of uric acid remained unprecipitated in every 26 C. C.

With these results, as data, the following calculations were made:—

a. 200 C. C. of urine gave 0·0572 gramme of uric acid. The filtrate and washing-water with 5 C. C. of hydrochloric acid, and at about 10° to 12° C. (50° to 54° Fahr.) = 270 C. C.

b. 200 C. C. of the same urine gave 0·0567 gramme of uric acid. Filtrate, &c. = 265 C. C.

After correction, the following is the amount of uric acid in this urine:—

a.	As found directly,	0·0572	gramme—	after correction,	0·06760.
b.	”	0·0567	”	”	0·06690.
				mean .	0·06725.

c. 200 C. C. of the same urine, to which 0·1167 gramme of uric acid was added, yielded 0·174 gramme. Filtrate, &c. = 280 C. C. 12° C. (54° Fahr.).

d. 200 C. C. of the same urine, with 0·1148 gramme of uric acid, gave 0·1684 gramme of uric acid. Filtrate, &c. = 295 C. C. 12° C. (54° Fahr.).

After correction:—

For *a.* 0·1848 gramme uric acid.
0·0672 gramme contained in the urine.
0·1176 gramme uric acid instead of the 0·1167 gr. added.

For *b.* 0·1797 gramme.
0·0672 gramme contained in the urine.
0·1125 gramme uric acid instead of the 0·1148 gr. added.

In a further experiment, conducted in a similar way, 0·0549 gramme were, at a temperature of 12° C. (54° Fahr.), found instead of the 0·0543 gramme added.

The solubility of the uric acid in the acid fluid naturally increases with increase of temperature. As an average of six estimates, which were conducted with a similar quantity of acid, but at a temperature of 20° C. (68° Fahr.), only 96·6 per cent. of the uric acid employed was found again—the above corrections (26 C.C. fluid = 1 milligramme of uric acid) being adopted. A more extensive experiment showed, that at a temperature of 20° C. (68° Fahr.), and with the same amount of acid (200 C. C. fluid, 5 C.C. of hydrochloric acid, of sp. gr. 1·11), 17·5 C. C. of the filtrate held, on an average, 1 milligramme of uric acid in solution. The following estimates may also be introduced here:—

Temperature 20° C. (68° Fahr.). 17·5 C. C. filtrate = 1 milligramme of uric acid.

Uric acid employed.	Quantity found by direct experiment.	Filtrate and washing-water.	Corrected quantity.
0·1651 gramme.	0·1466 gramme.	330 C. C.	0·1647 gramme.
0·2375 "	0·2215 "	280 "	0·2375 "
0·2375 "	0·2203 "	275 "	0·2360 "
0·2375 "	0·2180 "	300 "	0·2351 "
0·1900 "	0·1746 "	280 "	0·1906 "
0·2228 "	0·2080 "	305 "	0·2254 "

VII. *Determination of the creatinine.* (Section LXIX.)

0·8938 gramme of creatinine were dissolved in between 2 and 3 C. C. of water, and diluted with absolute alcohol up to 160 C.C. Each 50 C. C. of this solution, in which 0·2793 gramme of creatinine was dissolved, were measured off, and precipitated by ½ C. C. of an alcoholic solution of chloride of zinc, of sp. gr. 1·195. After standing 48 hours in the cool, the precipitate was carefully removed on to a filter, dried at 100° C. (212° Fahr.), and the filtrate obtained always used again in the formation of the precipitate. The washing with absolute alcohol was commenced when the mother-liquor had completely run off. When dried at 100° C. (212° Fahr.) the following results were obtained:—

1. 0·2793 gramme of creatinine gave 0·4438 gramme of creatinine-chloride of zinc, corresponding with 99·2 per cent.

2. 0·2793 gramme of creatinine gave 0·4429 gramme of creatinine-chloride of zinc, corresponding with 99·0 per cent.

3. 0·2793 gramme of creatinine gave 0·4439 gramme of creatinine-chloride of zinc, corresponding with 99·2 per cent.

For the sake of correction, an estimate of the nitrogen was made with the creatinine-chloride of zinc: 0·3453 gramme, dried at 100° C. (212° Fahr.), gave 0·0798 gramme of nitrogen, corresponding with 23·1 per cent. of nitrogen; whilst, according to calculation, it should have amounted to 23·21 per cent. Consequently, 100 parts of the zinc-compound correspond with 62·44 per cent. of creatinine.

From the above calculations it appears, that the determination of the creatinine, by means of chloride of zinc, approaches closely in accuracy to the determination of potash by bi-chloride of platinum.

VIII. *Determination of the albumen.* (Section LXX.)

Double analyses by weight were very carefully made of clear filtered urine, mixed with a solution of albumen.

1. *a.* 100 C.C. gave 1·130 gramme of albumen, dried at 100° C. (212° Fahr.)
b. 100 C.C. „ 1·107 „ „
2. *a.* 100 C.C. „ 0·624 „ „
b. 100 C.C. „ 0·616 „ „
3. *a.* 100 C.C. „ 0·600 „ „
b. 100 C.C. „ 0·588 „ „

IX. *Determination of the lime.* (Section LXXI.)

0·222 gramme of phosphate of lime was converted into carbonate (as described in Section LXXI. 1), and then dissolved in 20 C. C. of hydrochloric acid, each cubic centimetre of which corresponded with 10 milligrammes of lime. For correspondence, 10·2 C. C. of caustic soda of equal strength were employed; consequently, 20 — 10·2 = 9·8 C. C. of hydrochloric acid were saturated by the lime.

The 0·222 gramme of phosphate of lime, therefore, contained 0·098 gramme of lime = 44·14 p. c. of CaO. The calculation by weight gave 44·20 per cent. CaO.

Every 100 C. C. of such urine treated in this way yielded a percentage of 0·0420 and 0·0423 of lime.

X. *Determination of the ammonia.* (Section LXXII.)

The sulphuric acid employed in these experiments contained 0·5304 gramme SO_3 in 10 C. C., corresponding with 0·22542 gramme NH_3. 22·1 C. C. of caustic soda were employed for the saturation of 10 C. C.; consequently 1 C. C. of caustic soda corresponded with $\frac{0\cdot22542}{22\cdot1} = 0\cdot0102$ gramme NH_3.

1. 10 C. C. of fresh urine were treated directly with milk of lime. After 48 hours, the NH_3 developed corresponded with 0·6 C. C. of caustic soda. Consequently the urine contained 0·081 per cent. of NH_3.

2. 40 C. C. of the same urine were freed from their extractive and colouring matters by 40 C. C. of a mixture of sugar-of-lead-solution and basic acetate of lead. 20 C. C. of the clear filtrate, corresponding with 10 C. C. of urine, developed the same quantity of NH_3 in 48 hours; 0·8 C. C. of caustic soda were saturated.

After another 48 hours, neither of the liquids tested had given off the smallest quantity of NH_3.

3. 0·2343 gramme of sal-ammoniac, dried at 100° C. (212° Fahr.), were added to 10 C. C. of the same urine. At the conclusion of the experiment, 14·1 C. C. of soda had been used in the saturation of the 10 C. C. of sulphuric acid. Hence the NH_3 developed corresponded with $22\cdot1 - 14\cdot1 = 8$ C. C. of soda.

The 10 C. C. of urine alone corresponded with 0·8 C. C. of soda; consequently $8\cdot0 - 0\cdot8 = 7\cdot2$ C. C. of caustic soda remained for the sal-ammoniac added. 7·2 C. C. of soda correspond with $(7\cdot2 \times 0\cdot0102) = 0\cdot07344$ gramme of NH_3, and this with $17 : 53\cdot64 :: 0\cdot007344 : x = 0\cdot2309$ gramme sal-ammoniac. Thus 0·2309 gramme were found in the place of the 0·2343 gramme added.

4. 10 C. C. of another urine were treated directly with milk of lime. The NH_3 developed corresponded with 1·25 C. C. of soda, consequently the urine contained 0·1275 per cent. of NH_3.

After another 48 hours no more ammonia was developed.

5. 10 C. C. of the same urine were treated with 0·1744 gramme of sal-ammoniac. At the conclusion of the experiment, 15·4 C. C. of soda had been employed for the saturation of the 10 C. C. of SO_3. The NH^3 therefore developed corresponded with $22\cdot1 - 15\cdot4 = 6\cdot7$ C. C. of soda. The 10 C. C. of urine alone corresponded with 1·25 C. C.; hence, $6\cdot7 - 1\cdot25 = 5\cdot45$ C. C. of soda-ley remained for the sal-ammoniac added. 5·45 C. C. correspond with $(5\cdot45 \times 0\cdot0102) = 0\cdot05559$ gramme of NH_3, and this with 0·1747 gramme of sal-ammoniac; consequently for 0·1744 gramme employed, 0·1747 gramme sal-ammoniac was found.

THE

SEMIOLOGY OF THE HUMAN URINE.

THE

EMIOLOGY OF THE HUMAN URINE,

ESPECIALLY DESIGNED FOR

THE PURPOSES OF THE PHYSICIAN;

CONTAINING

DESCRIPTION OF THE SIGNS INDICATED BY ALTERED
CONDITIONS OF THE URINE;

AS WELL AS

A GUIDE TO THE INVESTIGATION OF
INARY CALCULI, AND OTHER URINARY CONCRETIONS.

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MDCCCLXIII.

INTRODUCTION.

The investigation of the urine has been resorted to from the earliest times as an important help in the diagnosis and study of disease. Previously, however, to the chemical and microscopical examination of it, the investigation was of very little scientific value. The inspection of the urine was often resorted to by charlatans, in order to deceive the credulous public; and consequently for a long time it came into discredit both with the scientific physician, and the educated classes.* The progress of Organic Chemistry, and the general study of the microscope, first gave its scientific character to uroscopy; and no one, indeed, needs now to be informed, that it constitutes an important and necessary part of semiology and diagnosis. The scientific studies, upon which uroscopy is founded, have, during the few past years, made remarkable progress, and every day adds something new to the discoveries already made.

Hence a farther and renewed investigation of this subject becomes necessary; but, under present circumstances, it becomes one of great difficulty, because the practical tests, as practised by the physician at the bedside of the patient, and from which alone he draws his positive conclusions, cannot keep pace with the rapid progress of physiology and chemistry. For this reason the author has not attempted to introduce into his work everything that might be said in relation to this subject. He has preferred to treat only of that which can be accepted as positive, for long experience has shown him, that students, and even physicians, preferring what is novel and striking, often take up uncertain and even false ideas, and are thereby led into errors both of diagnosis and prognosis. For this reason, he has endeavoured in every case to determine accurately the degree of certainty or of probability, which may be attached to the different indications presented by the urine.

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* This ancient practice of the charlatans threatens again, at the present day, to re-appear. The Author had an opportunity, a short time ago, of knowing that dozens of specimens of urine were sent daily (and generally from long distances) to a female urine-inspector, who had a very extensive reputation; and that from these specimens alone both the diagnosis and prognosis of diseases were deduced. The descriptions were given in common language and indefinitely expressed, but were nevertheless received by the adherents of the doctoress as undeniable oracles,—the chief of her believers being people of the higher, and especially of the fashionable, classes of society. Under such circumstances, it becomes doubly the duty of the physician to point out what assistance a scientific study of the urine can really give in the diagnosis, prognosis, and treatment of different diseases.

The investigation of the urine for the purposes of the physician may be carried out in two different ways. It enables us to draw conclusions :

1. As to the existence of certain general conditions of the system, the state of the nutritive functions, the constitution of the blood, the digestion, &c. ;
2. And of certain local diseases of the urinary organs.

We shall consider the subject in the following pages, as far as we can, from both these points of view.

Besides this, the study of the urine sometimes enables us to arrive at conclusions concerning special facts and processes, a knowledge of which is of importance to the physician. Thus we are often able, from the mere inspection of the urine, to determine whether or not a patient is feverish. From the smell or the colour of the urine, we can tell that certain articles of food or medicine have been taken, for example, asparagus, oil of turpentine, rhubarb, &c. From the quantity of spermatozoa in the urine, we learn whether the discharge of semen has taken place during coitus or is the result of pollution. The presence of albumen in the urine enables us, under certain conditions, to decide that the patient is dropsical. Bile in the urine also indicates jaundice, &c.

The skilful physician takes advantage of these signs, in order to gain the confidence of his patient; but, as a scientific man, he should avail himself of them cautiously, and without ostentation. Abuse of his knowledge in this respect will stamp him in the eyes of his colleagues and of the public as a charlatan.

The study of the urine is often of great importance in therapeutics, informing us whether or not certain substances, which the sick person has used as medicine, have been separated with the urine. In the latter case, the physician is cautioned against the prolonged use of many medicines, which become dangerous by accumulation in the body, such as saltpetre, digitalis, strychnia, &c.

In the former case, the continued use of the agent, or an increased dose of it, is indicated; when, for instance, we desire to keep the body for a long time under the influence of an agent which exercises ts full effect slowly and gradually, such as iodide of potassium, alkaline carbonates, and the like. The importance of examining the urine for such purely therapeutical objects has not yet been sufficiently acknowledged in practice. Such examinations will, however, most certainly become more common, in proportion as the processes required in carrying them out, and which have hitherto been complicated and imperfect, are improved and simplified, and so rendered more applicable in the hands of the physician—an object which the author trusts that all chemists, who feel an interest in this subject, will keep in view.

If, however, the investigation of the urine has been hitherto neglected in reference to the particular points above referred to, it has, on the other hand, in certain ways been considered as of more importance than it really is. Many special facts will hereafter be mentioned under this head. One erroneous idea, however, which is founded upon an imperfect knowledge of the nutritive changes in diseases, and upon an ontological mode of considering the forms of diseases—not yet discarded by all pathologists—deserves refutation. This idea is widely spread, and is not unfrequently met with in works recently published on this subject. It is, that there is a special and characteristic condition of the urine corresponding with every kind of disease. But such a condition is, in reality, only met with in those rare cases in which the disease takes its name from some peculiar and well-defined condition of the urine. The urine, for example, in albuminuria must naturally contain albumen, in glycosuria sugar, in oxaluria oxalic acid, &c., or we should not be justified in applying such names to the diseases mentioned.

In other forms of diseases we very rarely meet with any special characteristic condition of the urine. It has, indeed, been often affirmed that the urine has a particular composition,.or possesses certain peculiar qualities, in typhus, pneumonia, &c., but such observations are, as a rule, supported on very insufficient data, or on investigations made during certain stages only of the progress of such diseases. The study of the urine in diseases of this nature, in which investigations have been made on a large scale, and at all stages of their progress shows (as I shall prove hereafter), that the condition of the urine in all acute diseases varies during the course of the disease, and that, too, with a certain degree of regularity. This change in the condition of the urine, moreover, depends less upon the particular nature of the disease, that is, upon its local phenomena, than upon certain general conditions of the body, such as the intensity of the fever, the state of the appetite and the digestion—or, in other words, upon the amount of food taken. This is also true of those chronic diseases during whose progress, as so often happens, acute exacerbations arise. The idea, for instance, so commonly entertained, that in Morbus Brightii the quantity of urea in the urine is diminished, is to a certain extent untrue; for in febrile conditions of the diseases, as well as in all fevers, an increase of the urea is generally observed.

For these reasons, I have thought it better to point out in the following pages only the *general* semiology of the urine. Its *special* semiology, that is to say, the description of the constitution of the urine in individual diseases, will be best considered under the head of each particular disease, and therefore under the head of special pathology.

To render more easy the explanation and the solution of any given question, the following pages have been divided into two chief divisions, and into several subdivisions.

The first division contains the qualitative changes of the urine, including the sediments. It contains four subdivisions:—

I. Changes in the colour, appearance, and odour of the urine.

II. The chemical reaction of the urine, and its significations.

III. The presence of unusual and abnormal constituents in the urine.

IV. Urinary sediments.

The second division comprises the quantitative changes of the urine, the increase and the diminution of the normal constituents of the urine.

It is subdivided into two parts:—

I. Quantitative changes, which are appreciable without the aid of chemical analysis, and which are of especial importance to the physician, by reason of their ready appreciation.

II. Quantitative changes, which require chemical analysis for their demonstration.

A guide to the investigation of urinary calculi and other urinary concretions is given in the Appendix.

I would refer those, who wish to study more minutely the changes h occur in the urine, with especial reference to their diagnostic fication, and their therapeutical indications, to my work on ases of the Kidney, which comprises an account of the changes rring in the urine in diseases generally. This work is con- :d in the *Handbuch der speciellen Pathologie und Therapie,* Bd. lited by Virchow, and published in Erlangen.

FIRST PART.

QUALITATIVE CHANGES OF THE URINE, INCLUDING URINARY SEDIMENTS.

I. CHANGES IN THE COLOUR, APPEARANCE, AND ODOUR OF THE URINE.

The changes included under this head are, of course, easy of appreciation; but of themselves they rarely lead us to any positive diagnostic and semiotic conclusions. They serve chiefly as hints and guides to a further investigation of the urine by other means. The mere inspection of the urine, therefore, is of little value to the physician.

SECTION LXXXIV.

COLOUR OF THE URINE.

The colour of the urine is sometimes an important sign, giving the physician valuable indications as to the nature of some of the diseased conditions of the body; but, generally speaking, it serves rather to point out to him the direction in which he must prosecute his inquiries.

The causes of the colour of the urine are colouring-matters, of whose nature and origin we have not yet obtained much certain knowledge. (Compare Sections IX., LIV., and CXIII.)

As medical men, we have to distinguish between normal and abnormal colour of the urine.

1. The *normal colour* of the urine is yellow, with a mixture of more or less of red. It may be nearly as colourless as water, or of a yellow, red, or reddish-brown colour.

These different shades of the healthy urine may be classed in the following groups:—

Pale urine—Colourless to straw-yellow.

Normally-coloured urine—Golden-yellow to amber.

High-coloured urine—Reddish-yellow to red.

Dark-coloured urine—Of a brownish tint; dark, beer colour.

Pale urine contains little colouring-matter, little urea, and, as a rule, also only a small amount of solid constituents. (The urine in diabetes mellitus must be excepted.) It is seldom very acid; frequently neutral or alkaline. It is passed in health after large draughts of fluids (*urina potûs*); and often by persons suffering from chronic diseases, such as chlorosis, anæmia, diabetes, and on recovery from severe acute diseases.

The existence of pale urine is an almost certain indication to the physician that his patient is not suffering from any acute febrile disorder. When the urine remains for a long time constantly pale, we may conclude that the patient is suffering from a certain degree of anæmia (oligocythæmia).

Normally-coloured urine gives us only the negative indication, that disease does not exist of a nature such as might be indicated by very pale or very high-coloured urine.

High-coloured urine is generally concentrated, rich in solid constituents (and therefore of high specific gravity); rich also in urea, and usually very acid. It occurs in cases in which the secretion of water by the kidneys is diminished, the secretion of the other constituents of the urine remaining normal, or even being increased. Consequently, this kind of urine is met with in perfectly healthy persons, after abundant meals (*urina chyli*), or when the individual has taken violent exercise, or has sweated much and drunk little. It occurs also in almost all febrile diseases, and becomes therefore an important sign to the physician. In hectic fever, for example, this condition of the urine often gives a more certain indication of the intensity of the febrile increase of the tissue-metamorphoses, than is afforded by the pulse or the heat of the body.

Dark urine, as a rule, indicates that an abnormal pigment is mixed with the urine. Further investigation, however, is required to ascertain its import and signification.

Occasionally, it is desirable to determine the colour of the urine with greater accuracy than can be attained by the above rules. In such cases, we proceed as pointed out in Section LIV., making use, in the conclusions thence derived, of the hints given in Section CXIII.

Heller has given another method for determining approximatively the quantity of ordinary colouring-matter of the urine—the urophæine, as he calls it. (See Ziegler, *Die Uroscopie am Krankenbette*. Erlangen, 1861. P. 24.) A little concentrated oil of vitriol is poured into a beaker-glass, and double the quantity of urine to be tested added to it. When quickly added, the mixture assumes more or less of a dark brown up to a tar-black colour. The quantity of urophæine is judged of from the intensity of the colouring. Ziegler states that the most intense colour of the urine under this test appears in cases of chronic disease of the liver, and especially in cirrhosis. He uses this test of urophæine as a means of diagnosis of these diseases.

The colour of the urine often depends upon the presence of different pigments—both of fluid pigments dissolved in the urine, and of solid pigments which belong to sediments. In such cases it is necessary to filter the urine, in order to ascertain more correctly the share which these two sorts of pigments take in colouring it.

2. *Abnormal colours* of the urine result from the presence in it of abnormal colouring-matters, which may be divided into two groups:—

a. Essential abnormal colours of the urine, arise within the body as the consequences of certain pathological processes, and present, therefore, important indications to the physician.

b. Accidental abnormal constituents of the urine.—These have been taken into the body as food, drink, or medicine, and after passing through the body, are separated again with the urine.

The most important of the abnormal colours of the urine are:—

a. The essential, are:

1. *The colouring-matter of the blood.* These colours give many different shades, according to the condition of the colouring-matter of the blood, whether separated from or united with the blood-corpuscles, decomposed or unchanged, or present in large or small quantity in the urine. The shades of colour may vary from blood-red, brown, dark-brown, up even to an inky tint.

For the indication and significance of the colouring-matter of the blood in the urine, see Sections XC. and XCI., and the cases 11, 12, and 13 in Section CXXV.

2. *Biliary colouring-matters* give to the urine a greenish-yellow, or brownish-green colour. (See Section XCIII.)

3. For the effects produced in the urine by the presence of

uroxanthine, and the products of its decomposition, *uroglaucine* and *urrhodine*, see Section IX. p. 48.*

Uroxanthine rarely has any appreciable influence on the colouring of the urine. It is only in those cases in which a very considerable quantity of uroxanthine is present, and where there is a deficiency of urophæine that the urine takes a lemon-yellow colour—in cholera and affections of the spine, for example. Chemical analysis is, however, always required to show with certainty the presence of uroxanthine. A few drachms of concentrated fuming hydrochloric acid are poured into a beaker-glass, and the urine—not more than 20 to 40 drops—then dropped into it. If uroxanthine be present the fluid passes from a violet-red up to a blue colour. (See Section XXXVI.)

Uroglaucine and urrhodine, products of the decomposition of uroxanthine, and probably identical with the blue and red colouring-matter of indigo (see p. 48†), sometimes, although rarely, appear in the urine, when it has undergone decomposition in the bladder, and a large quantity of carbonate of ammonia has been at the same time formed (cystitis, morbus Brightii). In such cases they may impart very striking colours to the urine—green, blue, and violet. Uroglaucine has a blue, and urrhodine a red colour, and from a combination of these colours with each other and with the ordinary colouring-matter of the urine many various shades of colour may be produced.

Thus the urine may be of a green—even of a beautiful grass-green, colour, when blue uroglaucine is mixed with a yellow urine. Again, it appears of a blue colour when the normal yellow is wanting and uroglaucine predominates; of a violet, when uroglaucine and urrhodine are present together; and reddish when urrhodine predominates.

Uroglaucine and urrhodine usually form sediments, and therefore the urine containing them must be filtered. Moreover, urrhodine dissolves in ether with a beautiful carmine-red colour, and uroglaucine in boiling alcohol with a beautiful blue colour.

According to Heller and his school (See Zeigler, p. 28, *op. cit.*), the quantity of uroxanthine thus found in the urine, may to a certain extent be employed as a measure of the degree of excitement which the nervous system has been subjected to, and especially the spinal cord. It is increased in spastic urine, after too frequent coitus, onanism, &c., so also in all cases of irritation of the urinary organs, in acute and chronic diseases of the kidneys—nephritis, morbus Brightii, peri-nephritis; and in many other diseases, such as typhus, intermittent fever, cholera, and uræmia. In my opinion, however, the therapeutical and diagnostic indications obtained from such investigations must be used with great reserve, as we know so little of the origin and signification of uroxanthine.

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* Compare Heller, Archiv für Chemie und Mikroskopie, 1852, s. 121.

† See also Kletzinsky, in Heller's Archiv, 1853, p. 414; and Sicherer, in Annal. der Chemie und Pharmac. Book 90, p. 120.

4. *Uroërythrine,* which exists only in abnormal urine, when dissolved in the urine gives it a red colour, and when precipitated with sediments of uric acid and urates, gives to them a brick-red, or rosy-red colour.*

Nothing certain is known concerning the composition and mode of origin of the uroërythrine in the body.

b. Accidental colouring-matters.—Different colouring-matters taken into the body with the food and drink, and with medicine, pass away from it again with the urine, and impart a colour to it. On this subject we possess much information,† but it is of less value to the physician than to the physiologist and the chemist.

Under this head may be mentioned two colouring-matters of interest to the physician, which are contained in drugs in frequent use, viz., rhubarb and senna. The colouring-matters in these drugs pass away with the urine and impart to it a colour similar to that of bile-pigment and the colouring-matter of blood. Both of them can render the urine brown, and even of a deep bluish-red colour. The nature of this colouring-matter is readily, however, distinguished from that of the blood by chemical agents. Urine, coloured by them, becomes clearer and of a lightish-yellow; on the addition of mineral acids, whilst urine coloured with blood does not become lighter, but in fact rather darker when these acids are added.

SECTION LXXXV.

ODOUR OF THE URINE.

The odour of the urine is but of little importance to the physician, s a sign of disease. Many substances, like the colouring-matters escribed in the last section, pass through the body and are disharged with, and impart a peculiar odour, to the urine. Such an dour will often indicate to the physician that the patient has taken ertain kinds of food or medicine. Thus, the urine has a peculiar dour when asparagus has been eaten. So also when turpentine has een swallowed, or inhaled in large quantity, it has an odour of violets. he smell of saffron and cubebs, &c., may also be detected in it.

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* Heller, in his Archiv, 1853, p. 391.

† See the experiments of Kletzinsky, in Heller's Archiv. für Chemie und Mikr., 1852, pp. 184, 211, 338.

It has been lately asserted by French pathologists (De Beauvais nd others), that the peculiar odour of asparagus, oil of turpentine, c., does not appear in the urine in cases of organic diseases of the idneys. However valuable this means of diagnosis may have been n cases of albuminuria, in which (in the absence of other signs) it as doubtful whether the kidney-affection was functional or organic, should, nevertheless, after making some experiments on the ubject, advise the observer to accept the statement with caution: found, for instance, the characteristic odour of asparagus and of il of turpentine present in the urine in two cases of albuminuria, n which subsequent *post-mortem* examination exhibited partial disrganization of the kidneys.

Healthy urine has also a specific odour, which Heller attriuted to the colouring-matter (urophæine). The odour, however, ost probably depends upon a variety of odorous matters, for Städeler, by the distillation of urine, succeeded in obtaining several olatile acids—phenylic, taurylic, damyluric, and damolic acids (Section VIII.). The odour of the urine is probably modified by the xcess of one or other of these acids.

The odour of the urine is peculiarly affected by the presence of uch carbonate of ammonia, the "urinous-odour" (as it is called) f patients, depending chiefly upon the presence of this salt.

SECTION LXXXVI.

THE CLEAR OR TURBID CONDITION OF THE URINE.

The urine is either clear or cloudy. Slight turbidity of it is produced by small floating flocculi. When the turbidity is more marked, and the urine has stood for some time, a precipitate takes place, and in this way a sediment is formed. The turbidity of the urine is hich was originally acid from the presence of acid phosphate of da, the ammonia may be unequally distributed through the urine, d render some portions of it alkaline, or it may produce an alka- ne atmosphere in the upper layer, whereby reddened litmus-paper rendered blue. Other portions of the urine may at the same time acid from the presence of acid phosphate of soda, and so redden ne litmus-paper. In like manner, we often notice, on the sur- ce of urine which has become ammoniacal, but which still has a ightly acid reaction, a pellicle of crystalline ammonio-phosphate magnesia, which, according to its chemical properties cannot ist in an acid fluid.

The chemical reaction of the urine yields the physician several seful indications, and is, moreover, a very simple test. It is there- re a valuable sign; but its real meaning can only be obtained by rther investigation.

It is not yet known positively what acid causes the acid reaction the urine. The acidity, as it would seem, does not depend upon e presence of a free acid, but is probably caused by acid salts, and most cases by the acid phosphate of soda. In many cases it may so depend upon acid salts of the urates, hippurates, lactates, and lphates.

The urine may lose its acid state, and may even become alkaline nder two essentially different conditions:

1. Carbonate of ammonia may be formed in the urine after it has een passed. In such case, when the quantity of the carbonate of mmonia is small, the urine is neutral; when it is large, alkaline. his development of carbonate of ammonia is caused by the decom- osition of urea, which, under certain conditions, by the absorption water, is converted into carbonate of ammonia.

$$\begin{array}{lr} \text{1 equiv. urea} & C_2\,H_4\,N_2\,O_2 \\ \text{4 ,, water} & \underline{\;H_4\quad O_4\;} \\ & C_2\,H_8\,N_2\,O_6 \end{array}$$

= 2 eqs. of carbonate of ammonia = $2\,(N\,H_4\,O,\,C\,O_2)$.

The conversion of the urea into carbonate of ammonia is caused y the presence of a ferment, of a body in a state of decomposition, hich decomposition it also excites in the urea. The mucus and us secreted by the mucous membrane of the urinary passages form ferment of this nature.* As urine invariably contains urea, it

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* I have made many experiments on this point. The urine of patients vhich, after standing from 12 to 24 hours, constantly gave an alkaline

Under favourable conditions the urine may become
the urinary passages—*i.e.*, before it is passed. The
may appear only after the urine has been passed; a
the urine will be acid when first passed, becoming
time. Urine almost invariably becomes alkaline in
time; but healthy urine is slow in becoming so, an
24 hours after being passed. Consequently, when
passed in an alkaline state, or, when passed aci
alkaline within 24 hours afterwards, we may conclud
stances exist which favour the decomposition of urea
considerations the physician may draw data for diagno

One point, however, is worthy of notice here, for i
may lead the observer into error. When urine, whi
become alkaline, is added to normal urine, the latter
ammoniacal decomposition much more quickly tha
naturally. The same thing occurs when urine is k
which contains any remains of ammoniacal urine.

When, therefore, we would draw any conclusions f
urine having become rapidly alkaline, *i.e.*, within 2
being passed, we must be sure that it has been kept
clean vessel. Hence, care must be taken that the u
the patient are not only emptied, but also washed ou
move every trace of the ferment-matter.

Urine, which has been rendered alkaline by carl
monia, turns red litmus-paper blue; but when the
and the carbonate of ammonia thereby driven off, th
paper becomes red again, in consequence of the preser

us to distinguish the alkalinity of the urine produced by carbonate of ammonia, from the alkalinity resulting from any other cause.

2. There is another cause, essentially different from that just described, which may render the urine neutral or alkaline. This cause is to be sought in the constitution of the blood. Under ordinary circumstances acid urine is secreted from the alkaline blood. The kidneys, therefore, through their secreting-cells must possess the property of separating acid salts from alkaline blood, or of forming them and passing them on into the urine. When, however, the blood is inordinately alkaline, the urine separated from it, as a rule, loses its acidity, and becomes neutral or alkaline. Thus the urine becomes alkaline, when a large quantity of caustic alkalies or of carbonates of the alkalies is taken into the system, and continues so, until the excess is separated from the blood.

Caustic soda, potash, magnesia, and lime, and their carbonates act in this way; so likewise do all vegetable acid salts, which are converted in the body into carbonates, and as such separated with the urine—the acetates, citrates, malates, and tartrates. All these bodies, when given as remedies in large doses, render the urine alkaline, and often in a very short time. Dr. Bence Jones found, that 120 grains of dry tartrate of potash, dissolved in four ounces of water, made the urine alkaline in 35 minutes, and that the alkaline reaction disappeared two hours later. Smaller doses, which are insufficient to make the urine alkaline, diminish the quantity of acid in it.

Food acts in a similar way, and, according to its nature, increases or diminishes the alkalinity of the blood. The urine of carnivorous animals is acid, of herbivorous animals alkaline. A similar action of food is observed in man, but in a less degree, his diet in most cases being a mixed one.

Certain organic processes also—results of the secondary metamorphosis of the food—undoubtedly influence the condition of the urine, by altering the alkaline condition of the blood. The nature of these processes, however, is at present very obscure, and it is only by very difficult and complicated investigations that we can hope to obtain an insight into them. The following conditions, however, may be noticed as probably influencing the state of the urine.

a. Dr. Bence Jones has pointed out, that the acid reaction of the urine increases and diminishes inversely with the secretion of the gastric juice. He asserts that the urine is most acid at the time when the stomach contains no acid secretion, or when the secretion has been returned again to the blood; and that, on the other hand, it becomes slightly acid or even alkaline in proportion as acid gastric secretion is separated from the blood.

Unfortunately the experiments performed by Dr. B. Jones on this point are not conclusive. In these, as in almost all his experiments on the quantitative analysis of the urine, the amount of acid is reckoned for 1000 parts of urine, and not for the particular hourly secretion of it, as it should be, if trustworthy conclusions are to be drawn from them. Experiments, which were performed partly by myself and partly by others under my superintendence, invariably showed that the greatest quantity of acid passed with the urine per hour was evacuated during the night, and the smallest quantity in the hours before midday; and that the quantity in the afternoon (after the chief meal of the day) was a mean between the two. These experiments, therefore, do not agree with those of Dr. B. Jones; they do not, however, positively contradict them, as other circumstances may influence the amount of acid in the urine.

Dr. B. Jones' hypothesis, theoretically considered, certainly seems reasonable enough. A quantity of acid is separated from the blood with the acid gastric juice, and the blood thereby rendered proportionally more alkaline; and consequently, at the same time, less acid is separated with the urine. It is, however, possible, that the alkali, which was combined with the acid of the gastric juice, may not remain in the blood, but pass into the bile; and if so, then the secretion of the gastric juice would occasion no alteration in the alkalinity of the blood, and consequently the secretion would not influence the quantity of acid in the urine. The investigations of Dr. W. Roberts confirm Dr. B. Jones' views. (See Section CXVIII.)

b. According to the experiments of Liebig and others, the juice of muscle is acid, or at least it becomes so immediately after being expressed. And as the urine in carnivorous animals is rendered acid by the constituents of the meat which they take as food, it is probable, that in men (as in animals) a part of the acid of the urine —perhaps the greater part of it—is derived from the fluid resulting from the metamorphosis of their own muscular tissues, which passes into the blood; or in other words, that the acid of the urine is in part a product of the metamorphosis of the muscular tissues. This, however, is not the place to discuss this difficult question.

For the purposes of the physician, the following are the chief points to be noticed in reference to the reaction of the urine:—

1. *Acid reaction of the urine.*—This is the natural state of the urine. The information which it affords, viz., the non-existence of certain diseased conditions of the body, is of a negative kind only. Further conclusions must be derived from the quantitative analysis of the acid in the urine. A very acid condition of the urine may favour the formation of certain sediments or concretions, especially of uric acid, or may occasion irritation of the kidneys and urinary passages.

2. *Neutral or alkaline reaction of the urine.*—This condition of the urine is always of importance to the physician; and shows that further investigation is required. We have, in such case, to note the following particulars:—

a. The alkaline action may depend upon the presence of carbonate of ammonia; the urine, in such case, turning reddened litmus-paper blue, and the paper becoming again red on drying. This condition always results (probably the only exception being the rare case, in which carbonate of ammonia passes directly from the blood into the urine) from decomposition of the urea in the secreted urine; the decomposition being caused by blennorrhœa or purulent secretion (however limited) of the urinary passages, whether idiopathic or symptomatic. The decomposition may depend on a great variety of causes.

b. Or, again, the alkaline reaction of the urine may result from the presence of a fixed base of potash, soda, or an alkaline earth. In such case the urine turns reddened litmus-paper blue, and it remains blue when dry. The causes of the alkaline reaction in this case may be:—the therapeutical use of caustic alkalies, of their carbonates, or of salts of vegetable acids; the too great indulgence in food containing them; or alterations in the products of the metamorphosis of the tissues, as above referred to.

The value of this neutral, or alkaline condition of the urine to the physician, as a semiotic sign, depends chiefly upon whether the condition is temporary or permanent.

If the urine is only temporarily neutral or alkaline, at a certain time of the day, some hours, for instance, after eating, or after certain kinds of food have been taken, or on particular days, then the condition is one merely of a physiological character, and has no practical pathological signification.

If, however, the urine is frequently or permanently alkaline, important semiotic and practical conclusions may be derived from it. These, however, are different in different cases:

1. The cause may be blennorrhœa or purulent secretion of the urinary passages. Diagnosis in this case is derived from the fact that the urine is alkaline, and contains mucus, or pus, and crystals of ammonio-phosphate of magnesia;

2. If the cause is the prolonged use of caustic alkalies, or their carbonates, or vegetable salts, the diagnosis is manifest enough;

3. With regard to the cause of the alkaline urine resulting from changes in the metamorphoses of the tissues very little is known; but the following may be mentioned as probable causes: partial arrestment of the metamorphosis of muscle, weakness of the nervous system, anæmia and chlorosis, defective nutrition, and enfeebled states of the body generally. Rademacher has rendered great service by calling especial attention to the fact* that a permanently alkaline condition of the urine is always an affection which requires the employment of steel and tonic medicines. From what, however, has gone before, it is clear that this is only true in a limited sense; and, moreover, the attentive observer will find in such cases, that the pale colour of the urine is generally a much surer indication that iron is required, than its alkaline condition, which, indeed, is often absent in patients of this kind.

The rational treatment of this condition is often very difficult. The great point, however, is always to discover and combat the cause of the alkalinity. It is very bad practice, arising from an erroneous idea of their chemical history, to give acids in all cases, whenever the urine is alkaline. When the alkaline state of the urine depends upon irritation of the urinary passages, originally excited by a too acid and irritating condition of the urine with the formation of uric-acid gravel, demulcent remedies with carbonates of the alkalies, or acetate of potass, are the proper remedies.

The assertion, so often repeated, that benzoic acid, taken internally, renders alkaline urine acid more readily, and with greater certainty than other acids, has not been confirmed by the results of numerous experiments performed by me on the point.

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* Rechtfertigung der verstandesrechten Erfahrungsheillehre. 2 Aufl., Bd. 2, p. 211.

III. Abnormal Constituents in the Urine.

All abnormal states of the urine which come under this head are of great practical importance, for they invariably indicate the existence of disease in the body. Every abnormal constituent of the urine, moreover, has its own special signification. We shall, therefore, proceed to consider separately the different abnormal constituents met with in the urine.

SECTION LXXXVIII.

Albumen.

I. The mode of ascertaining the presence of albumen in the urine has been already pointed out. (Section xix.) I shall, however, once again return to the subject, for the application of the test is not so simple as it might at first sight appear. Certain precautions are requisite. The physician may, indeed, readily be led into error, at one time overlooking the presence of albumen, and at another thinking it present when it really is not so.

Albumen is discovered in the urine:—

1. *By the addition of nitric acid.* When much albumen is present in the urine, nitric acid causes a deep white cloudiness in it, or may even convert the fluid into a whitish mass. In such cases no doubt can exist as to the presence of albumen in the urine. But it is different when only a small quantity of albumen is contained in the urine; in such case, a slight cloudiness may be overlooked, or it may depend upon the precipitation of other matters, and especially of urates—more rarely of urea—and may be mistaken for albumen. In such cases, therefore, we must add the nitric acid cautiously. The best process is that recommended by Heller. A small glass is filled two-thirds full of urine, and a little nitric acid then carefully and very slowly poured down its side, so as to allow of its collecting in the bottom. A well-defined turbidity will then be observed in the layer of urine above the nitric acid, if the urine contain albumen. This cloudy layer contrasts with the rest of the urine, and cannot be readily overlooked. In this way the minutest portions of albumen may be discovered in the urine.

A cloudiness of the urine depending upon urates may be also caused by the nitric acid, but in such case it is only well-defined in the lower layer of urine immediately over the acid, cloudy streaks being formed also in the still higher parts of the urine. A practised eye, which is able in this way to distinguish between albumen and salts of [illegible], when they occur together and occasion cloudiness of the urine. Immediately above the clear layer of acid there is a well-defined cloudy layer of coagulated albumen; above this there is another clear layer and then a layer which is rendered cloudy by urates.*

[illegible] the albumen in it is coagulated. Much albumen causes a flocculent coagulum: a small quantity occasions a cloudiness.

This test may also lead us into error. Boiling may cause a cloudiness to appear in the urine, when no albumen is present in it. This cloudiness is caused in most instances by phosphatic salts, and in some rare cases—in osteomalacia—results from the presence of a peculiar proteine-body, different from albumen.† Cloudiness arising from these causes is easily distinguished from the cloudiness of albumen, for it readily disappears on the addition of hydrochloric or acetic acid. The cloudiness, again, produced by the proteine-body, [illegible] which is not the case with the cloudiness [illegible] earths. The proteine-body is also [illegible] the fact that it is not precipitated by [illegible]

[illegible] circumstances, coagulated by boiling [illegible] when the urine is alkaline. Consequently, [illegible] the urine before [illegible] by the careful addition [illegible]

[illegible] boiling does not precipitate albumen [illegible] This happens when the urine contains [illegible] in such quantity as to form a compound [illegible] and boiling water [illegible]

W[illegible] urine does or does not [illegible] apply both tests [illegible]

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* Heller's Archiv für Chemie und Mikrosk., 1852, p. [illegible]

† Heller, op. cit., p. [illegible]

II. What indication does the presence of albumen in the urine yield to the physician?

The answer to this question, which has much occupied the attention of pathologists and therapeutists, is very difficult. Great caution, indeed, is required in judging of the signification to be attached to the presence of albumen in the urine. Erroneous conclusions may be readily adopted, and unfortunately often are so in this matter. Thus, some persons have held that albuminuria is a positive sign of organic disease of the kidney.

The following remarks will here serve to assist us in the matter of diagnosis and prognosis:—

I. The albumen in the urine may depend upon organic disease, connected with serious alteration and disorganisation of the parenchyma of the kidney. (Exudation into the renal tubuli, alterations in and separation of the epithelium,—Bright's disease, amyloid degeneration of the kidneys, &c.) We may be sure that this is the case when urinary cylinders, or epithelium from the urinary tubuli, are found in the urine. We may suspect that the albumen depends upon organic disease of the kidney, when dropsy is also present; or when albumen in large quantity has been present for a long time—weeks or months—in the urine. Prognosis, in such cases, is unfavourable; recovery seldom occurs; though it may do so in some exceptional cases, when the parenchyma of the kidneys is only partially diseased.

II. The albumen in the urine may depend upon some local disease of the urinary organs, there being no Bright's disease present.

The urine becomes albuminous when blood, blood-plasma, or pus is mixed with it. But, in such cases, the urine contains, in addition to the albumen, blood-corpuscles, colouring-matter of the blood, fluid or coagulated fibrine, and pus-corpuscles. The diagnosis of these abnormal constituents of the urine will be found in the following Sections.

It would appear that the urine may, in some rare cases, become albuminous through the mixture of semen with it.* Irritation and hyperæmia of the kidneys may also render the urine albuminous; in such cases, the capillaries of the kidneys are probably so altered as to permit the albumen to filter through them, and pass into the urine. This is sometimes observed after the use of powerful diuretics, cantharides, &c.; after ligature of the renal veins, or of the aorta below the origin of the renal arteries, after the injection of a large quantity of water into the blood, and especially under those conditions which occasion increase of the blood-pressure in the renal vessels. Many diseases undoubtedly exercise a similar influence on the kidney, and thereby render the urine albuminous.

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* Dr. Bence Jones' Animal Chemistry, 1850, p. 108.

III. There are certain alterations of the nutritive processes also, and of the blood in particular, which probably occasion the passage of albumen into the urine, independently of any local affection of the kidneys. But of these alterations and of their mode of action we know, as yet, very little. The following facts are worthy of consideration under this head:—

a. Albumen very often appears in the urine, when the blood contains much water and little albumen; Hyp-albuminosis, Hydræmia;

b. When albumen in solution is injected into the blood of animals, their urine sometimes becomes albuminous, and sometimes not. Experiments of this kind have led to the hypothesis (Corvisart, Schiff), that certain forms of albumen pass more readily than others through the walls of the renal vessels. It has also been conjectured, that particular modifications of the albumen of the blood, which are produced in disease by abnormal tissue-metamorphosis, occasion albuminous urine.

Whether or not any visible alteration of the kidneys, hyperæmia and enlargement of the blood-vessels, with partial separation of the renal epithelium, really exists in the cases *a* and *b*, here mentioned, cannot be ascertained. This much, however, is certain, that such affection of the kidneys, whatever its nature, is only temporary; and consequently, that it is not possible to decide as to the existence of any organic disease of the kidneys—Bright's disease—simply from the presence of albumen in the urine; other signs, such as fibrinous casts, are required for this purpose. We cannot, in fact, conclude with certainty as to the presence of Bright's disease, except in those cases in which the urine has been constantly, and for some length of time, albuminous.

If we have sufficient reason to believe that Bright's disease is not present, we have then to decide whether the albuminuria depends upon irritation of the kidneys, or upon some changed condition of the blood. The answer to this requires a further investigation into the case, and cannot in the majority of instances be given with certainty. The question is, however, often one of much importance as regards treatment, especially when we have to decide as to the use of diuretics.

Sometimes a quantitative analysis of the albumen separated with the urine is desirable, in cases in which we wish to know how much albumen is in this way removed from the body, and whether or not we have reason to fear impoverishment of the blood. Hyp-albuminosis. Hydræmia.

The following considerations will assist the physician in the quantitative estimation of the albumen. The percentage of albumen in the urine must not only be determined, but it must be determined for a given time, and, best of all, for 24 hours.

The quantity of albumen which is passed with the urine varies greatly, from a minimum of less than 1 gramme up to 20 and even 30 grammes in the 24 hours. Keeping these facts in mind, the loss of albumen through the urine may be considered under the following heads:—

The loss is insignificant, and has scarcely any influence over the blood or the metamorphic changes, when the quantity separated is less than 2 grammes in the 24 hours;

The loss is moderate when the daily quantity averages from 6 to 8 grammes;

The loss is considerable, when the quantity of albumen exceeds from 10 to 12 grammes in the 24 hours.

We very rarely meet with cases in which as much as 20 grammes and upwards of albumen are passed in the 24 hours; or in which such a quantity is passed for any length of time. 28·3 grammes was the maximum quantity observed in a great number of cases investigated by myself.

In endeavouring to ascertain what influence this loss of albumen has upon the constitution of the blood, and how far it operates in inducing an abnormal diminution of the albumen in the serum of the blood (Hyp-albuminosis, Hydræmia), we must proceed as follows: Let us suppose that all the most unfavourable conditions are present, so that the serum forms only about one-half of the whole mass of the blood, and that an adult has about 6000 C.C. of blood-serum, containing 8 per cent. of albumen, or 480 grammes of albumen in the whole.

Thus if we suppose, that so long as the albuminuria lasts no albumen is formed from the proteine-bodies which are taken as food, and from the hæmato-globuline of the broken-up blood corpuscles.

If now, we suppose, that an average of 10 grammes of albumen are passed daily, *i.e.*, 100 grammes in 10 days, the quantity of albumen in the blood would be reduced to 380 grammes, and the relative proportion of blood-serum from 80 to 64 per 1000 in that time. Such a condition would of itself indicate a moderate degree of hydræmia. A similar loss of albumen going on during 26 days would reduce the quantity of albumen in the blood down to 37 per 1000—which corresponds closely with the minimum amount of albumen in the blood-serum observed by Becquerel and Rodier.

Such considerations indicate, that in cases in which the albumen in the urine is very abundant, a high degree of hydræmia may be induced in a comparatively short space of time. Experience, however, tells us, that the action of albuminuria on the constitution of the blood is rarely ever, in fact, so considerable, except in cases attended with acute fever, and in patients in whom the appetite is lost, and the digestive powers prostrated. It must be remembered, that 100 grammes of meat contain from about 15 to 20 parts of proteine-matters, which, if the digestion is good, are almost wholly converted into a soluble form of albumen, and pass directly into the blood; consequently, a daily loss of 10 grammes of albumen may, under favourable circumstances, be replaced by an addition of three ounces of meat, or of a corresponding quantity of proteine-food to the daily diet. In fact, we often observe cases in which, when the digestion is tolerably good and there is no fever, a moderate degree of albuminuria continues for months, without producing any perceptible hydræmia.

The means ordinarily employed for ascertaining the quantity of albumen in the urine have been already described. Heller has given a process for ascertaining *indirectly* the quantity of albumen in the urine.*

It is applicable in most cases, where very accurate results are required. The following is the mode of proceeding:—A certain quantity of urine—10 to 15 grammes—are evaporated; the extract dried over sulphuric acid, and the quantity of solid residue determined. Another portion of the same urine is weighed in a small flask, treated with as much acetic acid as is required, boiled until the albumen is completely separated, and when cool placed on the balance and again brought to its original weight by the addition of water. The boiled urine is then filtered, and a certain quantity of the filtrate weighed off, evaporated, and the residue dried over sulphuric acid. The difference per cent. between the residue of the original urine and of the residue of the urine freed from albumen, by boiling, gives the quantity of albumen.

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* Heller's Archiv. 1852, p. 266.

This method of proceeding is, unfortunately, long and tedious, and can, therefore, be seldom resorted to by the physician, especially in cases in which he desires to ascertain for weeks and months together the quantity of albumen in the urine. In such cases the quantitative estimation of the albumen may be made by the polarising apparatus, as recommended by Hoppe (Virchow's *Archiv.* Vol II., p. 574). Another process recommended by Boedecker (Henle and Pfeufer's *Zeitschrift*, 1859, p. 321), viz.: the determination of the albumen volumetrically by means of ferrocyanide of potassium, gave very unsatisfactory results in my hands.

A much more simple process is followed when the physician wishes to obtain merely an approximative idea of the quantity of albumen in the urine, when for example, he would know whether the quantity is great or small, or whether it is on the increase or is diminishing.

The albumen in different specimens of urine is precipitated, either by boiling or by nitric acid, in test-glasses of exactly the same diameter, and the precipitate left at rest for 12 or 24 hours. The relative quantity of the albumen in the urine may be in this way readily estimated. The urine of different days, after precipitation, is preserved, and by a comparison of the relative amount of albumen in each specimen we learn whether the albumen diminishes or increases. The amount of albumen may be still more accurately determined if, instead of using the ordinary test-glasses, we pour the boiled urine into glass-tubes of exactly similar diameter ($\frac{1}{2}$ to $\frac{3}{4}$ of an inch), which are closed at bottom by a smoothly cut and well-fitting cork. In the course of 12 to 24 hours when the albumen is completely precipitated, we can, by placing a measure by the side of the tube, determine, in 10ths and 100ths, what proportion the albuminous precipitate bears to the urine itself.

It must be remembered, however, that in this way we ascertain the relative, not the absolute, quantity of the albumen in the urine. Besides this, such methods of estimating the albumen are never altogether to be trusted. Thus for instance, the precipitated albumen will occupy a greater or a less space according as the albumen is thrown down in larger or smaller masses, and also according to the specific gravity of the urine. I have found by experiments, in which the quantity of albumen has been taken by weight as well as by volume, that errors to the amount of 30 to 50 per cent. may occur in this method of estimating it by volume. Consequently, the recent conclusions of French pathologists, relative to the separation of albumen in albuminuria under the influence of various agencies, in so far as they are founded on the estimation of the albumen by volume, must be received with great caution.

SECTION LXXXIX.

FIBRINE.

Fibrine sometimes appears in the urine in a coagulated as well as in a fluid state.

Coagulated fibrine appears in the form either of large particles visible to the naked eye, as blood-coagula in fact, which are readily recognised, and cannot be mistaken for any other body (see the following Section); or, more rarely, in the form of colourless, sometimes solid, and sometimes jelly-like coagula; or again, of very small particles visible only with the microscope, urinary casts, &c. (See Sediments.)

Fluid fibrine in the urine forms the so-called coagulable urine, which is characterised by the circumstance of fibrinous coagula forming in it some time, generally several hours, after it has been passed: sometimes the coagula are only found at the bottom of the glass, forming there a sort of adherent sediment in the lower layer of urine: sometimes the coagulum extends through the whole of the urine, and converts it into a completely gelatinous mass. Coagulable urine of this kind is very rarely observed in Europe; but is met with in other quarters of the world, and, according to Rayer, in the Mauritius.

The fibro-gelatinous mass thus formed may be readily confounded with that which is much more frequently observed with us, and which is formed by the action of carbonate of ammonia, in urine rich in it, upon pus-corpuscles contained in the urine, as often happens in cases of vesical catarrh. (See Sections CIV. and CV.)

Coagulable urine sometimes contains blood also. In such case we cannot be sure that the urine contains fibrine as well as blood, unless the fibrinous coagulum is so large that it cannot be ascribed to the presence of the blood only.

I once met with such a case, in a woman who was suffering from Bright's disease. Here, for a long time, a very pale-red fibrinous coagulum, containing numerous pus-corpuscles and a few blood-corpuscles, was regularly formed at the bottom of the vessels some hours after the urine was passed. The few blood-corpuscles present showed that the blood which they represented was not sufficient to produce the whole of the fibrinous coagulum.

Indication.—The presence of fibrine in the urine, whether in a fluid or a solid state, always indicates, that, at some part of the urinary surfaces, an exudation of a fibrinous fluid (blood-plasma) has taken place. In most cases the fibrine escapes out of the kidneys; but it may be exuded from any part of the urinary surfaces.

SECTION XC.

BLOOD IN THE URINE.

(*Blood-corpuscles.—Blood-coagula*).

A. *Test.*—The urine has the colour of blood; and under the microscope shows the presence of the characteristic blood-corpuscles. (Section XLIII.) If the quantity of blood be very small, we cannot be sure of finding the blood-corpuscles unless the urine has stood for some time. After standing the blood-corpuscles fall to the bottom as a red sediment, so that we may, indeed, in this way often recognise the presence of a very small admixture of blood with the naked eye. If any doubt exist as to the nature of the sediment, it must be examined by the microscope.

The blood may coagulate in the urinary passages, if the quantity of it be rather large, and so as to close them up, producing thereby dysuria, strangury or retention of urine, and sometimes occasioning the formation of calculi. Or the coagulation of the blood may take place in the urine after it has been passed. (See Section LXXXIX.)

B. *Indication.*—The presence of blood-corpuscles or of blood-coagula in the urine always indicates, that bleeding has taken place

in some part of the urinary
[illegible] its consequences
the place to mention all the
[illegible]. The following
in the matter:—

When the urine contains a
has most probably escaped either
from the ureters, or the bladder; in
kidneys themselves. Sometimes the
general [illegible] condition of the
may [illegible]. With this exception,
of the kidneys and the ureters is
[illegible], usually by distension of
addition to the hæmorrhage, of these
the pelvis of the kidneys, there
sometimes contains fragments of the
and [illegible]. fragments of calculi
in the course of [illegible]. Pain in the
only enable us to arrive at a correct
If we pass over [illegible] the ureters is also present.
ureters, the hæmorrhage, either about the kidneys
from the surface of the bladder, we may conclude, has
Congestion of the mucous membrane of the
of its vessels; vesical calculi; erosions or ulceration
or serious organic injury of the bladder, as
by cancer. The symptoms of disease of the
present in such cases generally point out to us
hæmorrhage; the nature of the disease, moreover,
cases, ascertained by close and careful observation.

Sudden or temporary symptoms of affection of the
[illegible] without any premonitory signs,
when the hæmorrhage has arisen in the pelves of the
ureters. Such affection happens, when the blood which
its way into the bladder coagulates, and thereby stops
thral opening, rendering micturition difficult or impossible
formed in the ureters and passed into the bladder may
effect.

If the quantity of blood in the urine is small, and
symptoms present to indicate an affection of the urinary
is probable, that the blood has escaped from the parenchyma

large amount of hæmato-globuline is set free, granular pigment collects in the blood, and may produce serious results by obstructing the capillary blood-vessels, especially the cerebral vessels. It therefore appears advisable to examine the blood microscopically in all such cases, to ascertain if it deposits pigment-matters, before giving a prognosis.

SECTION XCII.

FAT.

C. METTENHEIMER. *Archiv f. Gemeinsch. Arbeiten,* Bd. 1, Hft. 3. p. 374.

A. G. LANZ. *De adipe in urinâ.* Dorpati, 1852.

L. BEALE. *London Microsc. Journal,* January, 1853, 1, 2.—SCHMIDT's *Jahrbuch,* 1853, 7. p. 7.

KLETZINSKY in *Heller's Archiv,* 1852. p. 287.

Our knowledge concerning the origin and the signification of fat in the urine is still very incomplete. We know not, with any certainty, how often, in what quantity, and under what conditions it appears in healthy urine; and little has been hitherto ascertained of its origin in diseased states of the body. The subject, therefore, requires further investigation. It seems probable from what we do know of the matter, that the presence of fat in the urine will some day give us important information as being the indication of several pathological conditions, and particularly of fatty disease of the kidneys.

A. *Tests.*—To ascertain the presence of fat in the urine, we resort to the process pointed out in Section XXX. The best way of proceeding is the following:—

1. Sometimes we are able, with the unaided eye, to see specks of fat in the urine similar to what are seen swimming on soup. These spots must be further tested by trying whether the stain which they make on paper remains after the paper has been dried. In all cases the physician must be sure that the presence of the fat is not accidental—that it is not derived from any oily or fatty impurities accidentally attached to the urinals, &c. This source of deception is far from uncommon.

2. In other cases the fat is recognised by the microscope. It

appears in the form of drops or granules, well known to all microscopic observers, either free or enclosed in cells, in exudation masses, or in fibrinous cylinders, &c. To find these fatty particles we must either seek for them in the superficial layer of the urine, where they usually float on account of their light specific gravity, or at the bottom of the urine when the fat is enclosed in cells or coagula, which form sediments.

3. The fat, again, may be in such a minute state of division in the urine as not to be recognisable even with the microscope. In such case we must ascertain its presence chemically, as described in Sections XXX. C., and LXXVII.

B. *Indication.*—It would appear that fat in the urine, when not of mere temporary occurrence, is an indication of importance to the physician, as showing the probable existence of fatty degeneration of the kidneys, which may exist alone, or may be associated with contraction of the kidneys,—one of the numerous forms of the so-called Bright's disease. In the last case, the formation of fat occurs either in the secreting cells of the kidneys, the epithelia of the urinary canals, or it arises through fatty metamorphosis of exudations deposited in the kidneys.

It is, however, not improbable that fat in the urine may depend upon other causes besides those here mentioned. Thus it may depend:

Upon a fatty degeneration of the epithelial cells of the ureters and the bladder;

Or upon an excessive amount of fat in the blood, which possibly may occasion the passage of fat into the urine, unaccompanied with any degeneration of the parenchyma of the kidney:

If we wish to study this fatty condition of the urine more closely, it will be necessary to determine the amount of fat quantitatively; and this may be done either by an approximative estimate of the quantity; or, and more accurately, by chemically extracting and weighing the fat, which is passed with the urine in a given time—say 24 hours. The quantitative determination of fat may be ascertained by the process described in Section LXXVII., or, better still, after Kletzinsky's method. Kletzinsky first boils the evaporated urine with alcohol, to which a couple of drops of acetic acid have been added, again evaporates to dryness in a water-bath, and then extracts with ether. By this process the organic matter is more thoroughly exposed to the fat-dissolving power of the ether, and any saponified fat which may be present is robbed of its alkaline base, and incorporated with the ethereal extract. These processes are, however, troublesome, and require much time for their performance. Very few attempts of this kind have as yet been made; in fact, I am acquainted with no investigations in which the quantity of fat passed in a given time has been reckoned. The following experiments, however, may be of service:—

Kletzinsky found in the urine of different persons, who were suffering from Bright's disease, the following quantity of fat in 1000 parts of urine: 0·24, 0·26, 0·28, 0·35, 0·37, 0·48, 1·27.

Dr. Beale, on the other hand, found in one case 14 parts of fat in 1000 parts of urine.

SECTION XCIII.

BILE-PIGMENTS.

The bile-pigments met with in the urine are cholepyrrhine and biliverdine. The process required for showing their presence will be found in Section XXIV.

Indication.—In some rare cases traces of bile-pigment have been found in the urine of persons in perfect health, and particularly at the hot season of the year.[*] The bile-pigment is found present in large quantities only in cases of jaundice.

Its presence may be thus explained: The passage of the bile from the liver into the intestines being impeded, the bile enters by absorption into the circulation. By this means it accumulates in the blood, and is mingled with all the secretions, but most particularly with the urine. It is very doubtful, whether any *primary* accumulation of bile-pigment takes place in the blood, that is to say, whether it can pass directly into the urine from the blood, without having previously formed a constituent of bile, and been secreted from the liver.

The presence of bile-pigment in the urine is of no great value as a diagnostic sign, as jaundice is generally to be recognised by other signs. In cases in which the yellow colour of the skin and the conjunctiva is doubtful, the presence of the pigment in the urine may confirm the diagnosis.

[*] Scherer, Ann. d. Chem. u Pharm. Bd. 57, p. 180-195.

The biliverdine is generally present in the urine in greater quantity than the cholepyrrhine; sometimes only biliverdine is to be found in it. As cholepyrrhine appears to be an original pigment in bile, and biliverdine to result from changes in the original pigment, we may conclude, that in jaundice the greater part of the bile-pigment is changed either during its absorption, or after it has reached the blood, or during its passage into the urine.

SECTION XCIV.

BILIARY ACIDS.

The biliary acid which occasionally appears in the urine is cholic acid, or rather its two conjugate acids, taurocholic and glycocholic acids. Their presence is shown in the manner described in Section XXV.: By evaporation of the urine, extracting the residue with alcohol, and treating the alcoholic extract with sugar and sulphuric acid. (Pettenkofer's *Test.*)

Origin and Indication.—Cholic acid has hitherto been seldom found in the urine, and probably because it has been seldom sought for. From observations hitherto made it appears that its presence in the urine is closely related to certain diseases.

A considerable quantity of cholic acid is, under normal conditions, constantly poured out with the bile into the intestines. By far the greater part of it is absorbed and passes back into the blood; where the cholic acid is altered and, as such, disappears in a way which is not fully understood. If this change does not go on in the blood, then the cholic acid may accumulate in the blood, and a portion of it probably pass over into the urine. As yet we do not know what the conditions are, which prevent this disappearance of the cholic acid in the blood, and which favour its passage into the urine. We shall not be able to determine fully the diagnostic and prognostic value of the presence of cholic acid in the urine until we have ascertained the nature of those conditions. We may, however, deduce a few conclusions, on the subject, from the facts before us.

Thus, for example, it is not altogether inexplicable why we, as a rule, find no cholic acid in the urine in cases of jaundice, where the urine is loaded with biliary pigment-matters. When the flow of bile into the intestines is arrested, the bile-pigment, whose normal mode of exit from the body with the fæces is closed, must pass away through a new channel; and, in fact, it is in part evacuated with the urine. The cholic acid, on the other hand, passes, normally, in great part back again into the blood, and there disappears; as therefore in jaundice no change takes place in this respect, we can readily understand why, as a rule, cholic acid is absent from the urine in this disease.

Moreover, as the disappearance of the cholic acid takes place in the blood and not in the liver, we should not, as a rule, expect to find cholic acid in the urine in diseases of the liver, but rather in those diseases of the blood in which the normal decomposition of cholic acid in the blood is arrested or impeded. It might be anticipated that this acid would only be found in the urine in those diseases of the liver which are accompanied with an increase of the biliary secretion; in such case the cholic acid accumulates in the blood, and its decomposition there is not complete.

SECTION XCV.

Sugar.

To find sugar in the urine we must proceed according to Section XXI. D. If the urine contains a large amount of sugar, the test may be performed without difficulty. The dark reddish-brown colour, which saccharine urine assumes when treated with caustic potash, and boiled for some time, is a sufficient proof. A further proof may be obtained by testing the urine with caustic soda or potash and sulphate of copper, or with bismuth and indigo-carmine. A certain degree of caution is, however, requisite in the use of the last test. When, for instance, the copper-solution (Fehling's or Barreswill's test) described in Section LXV. B. has been long prepared, the tartaric acid in it readily decomposes, so that on applying the test, boiling may produce an appearance of the presence of sugar, where none really exists.* Hence it is advisable always to prepare the fluid immediately before using it.

The oxide of copper is also reducible by other substances, which are almost constantly present in the urine, by uric acid and mucus. I have frequently seen experienced physicians thus led into the error of believing sugar present in urine which contained none. It is therefore well to apply the other tests mentioned, to control the copper-test.

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* Kletzinsky in Heller's Archiv, 1853. Heft 1, p. 20.

In cases, where the tests here named give no decisive results, we may be sure that the urine contains at most only a very inconsiderable quantity of sugar. Occasionally, however, we may wish to know whether or not the urine is perfectly free from sugar, or whether it contains a very small quantity—a mere trace—of it. To answer this question with certainty is difficult. The complex proceeding, described in Section XXI., must be gone through. (Preparation of an alcoholic extract of the evaporated urine, of a saccharate of potash, &c.)

To make an accurate quantitative analysis of the sugar in the urine, we must proceed according to Section LXV. The method of analysis there given is, however, rather complicated, and will therefore probably be entrusted, in most cases, by the physician to the chemist. In order to learn accurately the progress of the secretion of sugar, the quantity of sugar produced in a given time should be noted—the number of grammes of sugar, for instance, secreted in one hour. The sugar-contents of urine may be much more quickly determined by a polarising apparatus than chemically; by this means sufficiently accurate results may be obtained in a very short time.

Comparative trials of the accuracy of the different processes employed to determine quantitatively the sugar in the urine (the copper-, the fermentation-, and the polarisation-tests) have been made by Wicke and Listing. (Henle und Pfeifer's *Zeitschrift Neue Folge*. Bd. vi., Heft 3.)

Attempts have also been made to determine the quantity of sugar in the urine from its specific gravity; and for this purpose tables have been drawn out to show the quantity of sugar, which urine of a certain specific gravity should contain. This method is much practised in England, but, as Dr. Bence Jones has shown, it is very inaccurate, and cannot be employed if an accurate estimation is required.*

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* Dr. Bence Jones, in the Medical Times and Gazette, Feb. 4, 1854, gives the following striking illustrations of this :—

In consequence of the difficulty attending the employment of the methods here mentioned for determining the quantity of sugar in urine, I have proposed another process, which, however, gives only approximative, not absolutely accurate, results. It is simple, and, as a rule, fully sufficient for all the purposes of the physician, who in most cases requires only to ascertain, there or thereabouts, the quantity of sugar in the urine, and whether the quantity increases or diminishes. The process is founded on the fact, that saccharine urine, when boiled with caustic potash, assumes a yellowish-brown colour, and that from the intensity of the colour the quantity of sugar may be determined by the aid of a scale of colours, in the same way as the pigment-matter of the urine (See Section LIV.).

The way of proceeding is as follows :—A scale of colours is first of all made. A quantity of grape-sugar, accurately weighed,—from ½ to 1 gramme—or, if this cannot be obtained pure, of common cane-sugar is dissolved in from 20 to 30 C.C. of distilled water. (If cane-sugar is used, a little sulphuric acid is added, and the mixture is boiled for some time, until, in fact, the cane-sugar is converted into grape-sugar.) Double its volume of a moderately concentrated solution of caustic potash is then added to the solution of grape-sugar, the mixture boiled for five minutes, and allowed to stand half-an-hour. The fluid, which has become of a dark brownish-black colour, is then diluted with water, so that 1 C. C. shall contain 10 milligr. of sugar.

A scale of colours is then formed from this fluid in the following way :—We take six test-tubes of exactly the same diameter; in the first, we pour a mixture of 19 parts of water and 1 part of the coloured fluid; in the second, 9 parts of water and 1 of the fluid; in the third, 8½ parts of water and 1½ of the fluid; in the fourth, 8 of water and 2 of fluid, and so on. In this way we obtain a scale, whose divisions show in 1 C. C. of the fluid ½, 1, 1½,

Urine of	1023	sp. gr.	contained	in one ounce	2·2	grammes	of sugar.
„	1025	„	„	„	2·1	„	„
„	1026	„	„	„	4·0	„	„
„	1027	„	„	„	2·3	„	„
„	1027	„	„	„	4·5	„	„
„	1028	„	„	„	14·5	„	„
„	1029	„	„	„	3·3	„	„
„	1030	„	„	„	3·6	„	„
„	1030	„	„	„	7·25	„	„
„	1031	„	„	„	14·5	„	„

2, 2½, and 3 milligrammes of sugar. If now, we hold the stand containing the tubes against the window, and observe the colours by transmitted light, we may, with a little practice, readily recognise, by the intensity of colour, the particular shade belonging to each division of the scale.

We now measure off a certain quantity, 10 to 20 C. C., of the saccharine urine to be examined, boil it with at least an equal volume of caustic potash-solution, allow it to stand for half-an-hour, until the dark-brown colour is completely formed, and then dilute it with water,until its colour approximates as closely as possible to the colour of one of the divisions of the scale. In this way we learn, approximatively, how much sugar 1 C. C. of the diluted urine contains, and can from thence very easily reckon the total amount of sugar in the urine examined.

Indication.—The explanation of the cause of the presence of sugar in the urine is very difficult. It may be well, therefore, to keep in view the facts relating to the subject which are most important to the physician.

In a practical point of view the subject may be considered under two heads:—

1. In one case the urine not only contains large quantities of sugar, but the sugar is also for a long time together constantly present in it. Such urine is rarely ever free from sugar, and only when the patient has been fasting.

2. In the other case, the urine contains only traces of sugar, or the sugar is a temporary accident, or it is present for a short time continuously, or in an intermittent way, the urine being free from it during intervals.

In the first case, we may conclude, that the well-known disease diabetes mellitus, glycosuria, is present. In such case, there are, usually, other concomitant symptoms, which serve to assist the diagnosis and prognosis—a large quantity of urine of high specific gravity, great thirst, wasting, dry skin, &c. This is not the place to enter into a general description of the origin, the cause, the progress, and the complications of diabetes mellitus; and I will only remark, that the physician in all such cases is justified in making, if not absolutely an unfavourable, at least a very doubtful prognosis.

According to the observations of Warneke, Seegen, myself, and others, cases occur in which the urine temporarily, for a longer or a shorter period, contains a largish quantity of sugar, the subject of physician. Its value, when present, as a sign of disease, must be decided by future investigations.

SECTION XCVI.

ACCIDENTAL ABNORMAL CONSTITUENTS.

Under this head are comprised the various abnormal constituents of the urine, which are derived from food, drink, drugs, &c., and pass into the urine either changed or unchanged. They render the urine abnormal; but the abnormity is not in all cases to be considered as a pathological indication.

We have already, on several occasions, spoken of these accidental constituents of urine, their tests, and signification. (See Section XLVIII.) Their presence in the urine is of especial interest to the chemist and the physiologist,—to the chemist, in bringing under his notice various products of the decomposition of complicated organic bodies; and to the physiologist, in explaining the changes which different substances undergo in passing through the body in man and the lower animals, and in thereby throwing light on the subject of the intermediate metamorphoses of the tissues.

A knowledge of these constituents is also of importance to the hysician, and in the course of time will doubtless become much ore so. Their presence in the urine is an indication to the hysician that the patient has taken certain foods, drinks, or drugs. hus, from the smell of the urine we can conclude, that asparagus, l of turpentine, saffron, cubebs, &c., have been introduced into the dy. The colour of the urine indicates the presence of many getable substances, rhubarb, senna, certain pigment-containing ots and fruits; and the presence of other bodies which pass into ine may be shown by chemical analysis.

Of still more importance is it to the physician to know whether tain medicines are separated with the urine, and if so, in what antity. The answer to this, in many cases, would show whether atient should continue the use of them or leave them off.

In many cases of poisoning also, the poison may be found in the ne; consequently its examination becomes of importance in dical jurisprudence, as well as in diagnosis and therapeutics.

The following bodies are those whose presence in the urine is of especial interest to the physician:—

(The processes for ascertaining their presence are in many cases complicated, and are too long for introduction here. The reader is therefore referred to Section XLVIII., and to the Treatise of Kletzinsky, *Wiener Medic. Woch.*, 1857 and 1858.)

Lead sometimes passes into the urine in cases of lead-poisoning, and after the therapeutical use of preparations of lead. Its demonstration in the urine is difficult, and is not always successful. See also Folwarczny, *Weiner Zeitschr.*, N. f. II. b. 1859.

Copper may be generally found in the urine in cases of poisoning by copper (Kletzinsky).

In cases of *mercurial poisoning* and *mercurial treatment* the demonstration of the presence of the mercury may be of interest. In the last case we may wish to know whether the mercury still exists in the body, or has been wholly eliminated. For the processes which serve for this, see Section XLVIII.

Salts of zinc pass readily into the urine, and their presence there is easily recognised. (Kletzinsky.) *Nickel and cobalt*, both of which, and especially nickel, act as poisons, may be recognised in the urine. *Arsenic and antimony* also pass into the urine, and may be found there by well-known processes, by means of Marsh's apparatus.

The presence of *iodine* in the urine is sometimes of interest to the physician, as a sign of the system being under its influence. The quantity of iodine in the urine may be very accurately estimated. (See Section LXVI.)

In the internal administration of carbonates of the alkalies, and of organic alkaline salts (acetates, &c.), given as diuretics, or to neutralise an excess of acid in the urine, it is important that the physician should have some means of determining how long he may safely continue the use of such remedies,—when he should leave them off, and when continue their use. In such case the chemical reaction of the urine is the best indication. As long as the urine remains acid these remedies may be employed without injury, the system not being saturated with them. If, however, the urine is distinctly alkaline, not from the presence of carbonate of ammonia (see Section LXXXVII.), but through an excess of the fixed alkalies, it is best in most cases to omit the remedy for a time, and return to its use when the urine again becomes acid.

These remedies should be taken when the stomach is empty, as during the two or four hours subsequent to a meal the urine is less acid, and sometimes even alkaline. (See Section CXVIII.)

SECTION XCVII.

IV. URINARY SEDIMENTS.

By the term sediments of the urine is understood the solid, insoluble matters, which at first are usually found in suspension in the urine, and which after a longer or shorter time sink and form a precipitate. The precipitate forms more rapidly and completely the larger and heavier the particles are which are suspended in it; and more slowly and imperfectly the fewer and lighter they are.

Small quantities of sediments, which are composed of very fine molecules, do not readily subside, and are easily dispersed by shaking, are comprised under the head of *cloudiness, turbidity,* when their presence can be recognised only by an obscurity and lessened transparency of the urine. Sediments, which are seen by the unaided eye to consist of small sandy-like particles, are called sand or gravel.

Sediments often yield important information to the physician, enabling him at once to recognise certain changes in the urine, which otherwise would require tedious chemical investigation. No doubt chemical tests are sometimes required to demonstrate the nature of urinary sediments; and a microscopical investigation even still more frequently. The microscope, indeed, is absolutely necessary in making an accurate diagnosis of urine-sediments.

The semiotic indication of urine-sediments, like that of the urine, has a double character:

1. They indicate the existence of certain changes in the general nutrition of the body. They point out that an excessive amount of certain substances are separated with the urine, and have therefore been produced in the body: for example, uric acid, hippuric acid, oxalic acid, &c. By their aid, we are thus often able at a glance to obtain valuable information of a kind which serves the purposes of the physician, and which would otherwise require tedious chemical processes for its demonstration; 2. They point out to us certain local diseases of the urinary

system. Thus the presence of a purulent sediment indicates the presence of pus-formation at some part of the apparatus; and casts in the urine-sediment show a diseased condition of the parenchyma of the kidneys. The chemical composition of gravel points out the nature and constitution of vesical calculi, &c., whose presence has been recognised by other symptoms.

Some urine-sediments form after, and others before, the urine has been passed. It is from the latter kind that urinary calculi are formed under favourable conditions. For this reason it is often of importance to ascertain whether the sediment already exists in the urine when it is first passed, or whether it forms in it afterwards.

From these general considerations on urine-sediments, we shall now proceed to the consideration of the separate kinds of them.

SECTION XCVIII.

A. CRYSTALLINE SEDIMENTS.

SEDIMENTS OF URIC ACID AND OF URATES.

Sediments of this kind are very frequently met with in the urine, especially in connexion with acute febrile diseases; they occur more frequently than all the other kinds of sediments put together.

For their tests, see Sections XXXVI. and XXXVII.

The conditions, under which they are formed, are usually of a complex nature; and it is often very difficult in any given case to determine the influence which different promoting causes have had in their production.

Uric acid is one of the normal constituents of the urine, but it is soluble in it only in very small quantity. When, therefore, changes occur in the urine, which act so as to prevent the solution of the whole of the uric acid contained in the urine, that portion of the uric acid, which is no longer soluble, is separated as a sediment.

The changes in the urine, which accompany the formation of uric acid sediments, may be divided into two groups, each of which has a distinct practical value:—

1. In the one case, the quantity of uric acid which passes into the urine in a given time—say 1 to 24 hours—is greater than normal;

2. But if the urine secreted contains much less water than normal, or in other words is very scanty, uric acid sediment may be formed, although the separation of uric acid, from hour to hour, be not greater than normal.

The presence of uric acid sediment in the urine is, therefore, no proof that there is an absolute increase of the quantity of uric acid formed and secreted, as many physicians seem to think. We are not justified in coming to such a conclusion, unless we have ascertained by means of the process described in Section LXVIII., that the quantity of uric acid passed in a given time—a certain number of hours—is greater than normal.

The usual causes which give rise to the formation of uric acid are the following:—

1. Uric acid salts are much more soluble in hot than in cold water. Consequently, urine which is nearly saturated with these salts at the temperature of the human body, will throw down a sediment consisting of urates as the urine cools. We frequently observe that urine which is perfectly clear when passed, becomes cloudy, through a separation of its urates, as it cools.

It is evident that uric acid sediments cannot easily occur in this way within the body during life, because the urine in the bladder cannot undergo the necessary degree of cooling, except in the very rarest cases. Urine, however, saturated with urates may, by the action of endosmosis, undergo further concentration within the bladder, and a portion of its salts be thus rendered insoluble, and form a sediment in the bladder; but such a case must be very uncommon.

2. The neutral salts of uric acid are more soluble than the acid salts, and the acid salts than free uric acid. Consequently, a sediment is formed whenever the neutral salts in urine, which contains a large quantity of them, are from any cause converted into acid salts, or into free uric acid.

We see this change occur out of the body, when the urine undergoes acid fermentation, see Section I. It may also take place within the body, when the acid fermentation of the urine occurs in the bladder, which, indeed, rarely happens; or, and as it would seem, more frequently, when very acid urine is secreted and mixed within the bladder with urine, that is only slightly acid, or alkaline: in such case the acid urine abstracts the base, wholly or in part, from the neutral urates.

It is probable that the fermentation of the urine may also occasion deposits of urates in other ways than by the formation of an acid. The urine-pigments, indeed, appear to aid materially in the solution of uric acid in the urine. Consequently, if the urine-pigment be partially altered and decomposed by the fermentation, a portion of the urates will be precipitated.

So much for the theory of the formation of these sediments. Let us now turn to their practical indications.

Uric acid sediments most frequently occur in the course of acute febrile diseases, or during the febrile exacerbations of chronic diseases. In such cases several of the above-mentioned predisposing causes are generally in action at the same time: namely, diminution of the watery part of the urine, and therefore of the quantity of urine, absolute increase of the uric acid, strongly acid urine, and a large amount of pigmentary matter in it. The sediment, in such cases, generally appears some little time after the evacuation of the urine; it is occasioned, in part, by the cooling of the urine, and in part by its commencing fermentation, and the decomposition of the pigment matters, in which urine of this kind is usually very rich.

The appearance of such sediments varies much; sometimes they are of a brick-red colour, sometimes of a rose, a cinnamon, or sealing-wax colour. Under the microscope they usually present a fine granular form. They generally consist of neutral or acid urates, usually combined with soda, and sometimes, though rarely, with ammonia, or lime.

Their simplest diagnostic mark is that the turbid urine which contains them becomes clear when heated, and again turbid on cooling.

They indicate certain alterations of nutrition, which occur during most febrile states of the body—increased formation of uric acid and of urine-pigment, together with diminished secretion of water through the urine. They are often considered as critical. And there is some reason in this view, in so far as that the separation of a superfluous amount of uric acid from the blood may be considered as a favourable sign, and its retention in the blood capable of producing evil effects. They have, however, very often decidedly no critical signification in reference to the disease which they accompany; for we frequently observe that the chief symptoms of the disease continues undiminished for a long time after their appearance.

Occasionally, sediments of this kind occur in perfectly healthy persons, when the above-mentioned conditions are present; they occur, for example, after violent bodily exercise, excessive eating, or great sweating, with consequent diminution of urine; so also after a night's debauchery or a summer pedestrian excursion.

Such sediments are almost invariably formed out of the body, and consequently rarely occasion the formation of urinary concretions.

No practical good is derived from determining the nature of the base with which the uric acid is combined in such sediments, *i. e.* whether the sediment consists of urate of soda, urate of ammonia, or urate of lime.

Uric acid is more rarely met with as sediment in urine. As such it generally appears in the form of largish crystals or as crystalline masses often visible to the naked eye, sometimes alone and sometimes imbedded in a sediment of urates. Uric acid sediment is formed when the urine becomes acid through any of the above-mentioned causes; and sediments of the urates may, indeed, be artificially converted into a crystalline sediment of uric acid by the addition of an acid.

It is of importance in this case to note, whether the sediment is formed after the evacuation of the urine, or previously—*i. e.* within the bladder, or the kidneys. If the latter is the case, there is reason to fear, by its long continuance, that uric acid calculi may form either in the kidneys or in the bladder.

SECTION XCIX.

HIPPURIC ACID.

W. DUCHEK.—The Presence of Hippuric Acid in Human Urine. *Prager Vierteljahrschr.* 1854, vol. 3, p. 25.

W. HALLWACHS.—On the Origin of Hippuric Acid in the Urine of Herbivorous Animals. *Annal. d. Chemie et Pharm.* 1858, vol. 105, p. 207.

R. WREDEN.—Quantitative determination of the Hippuric Acid by means of Volumetrical Analysis. *Journ. f. pract. Chemie.* 1859, vol. 77, p. 446.

A. Lücke.—On the Presence of Hippuric Acid in Human Urine and its Tests. *Virchow's Archiv.* 1860. v. 19. p. 196.

We place hippuric acid under the head of the sediments, because it generally appears as a sediment in those cases which interest the physician; and because in this form its presence is more readily shown by aid of the microscope, than chemically by evaporation of the urine, &c. Section XXXI.

Sediments of hippuric acid are rarely met with. Under the microscope they usually appear as rhombic prisms, and sometimes as needles. *Plate I. Fig.* 1. They may be confounded with crystals of uric acid or of ammonio-phosphate of magnesia. From the latter, they may be easily distinguished by the circumstance, that they do not disappear on the addition of hydrochloric acid; and from the former by the fact that they do not produce the characteristic murexide-reaction. Sometimes the sediment is formed of a mixture of hippuric and uric acid crystals. I have, occasionally, seen needle-formed crystals of hippuric acid fixed like spears on the larger crystals of uric acid. In cases of this kind it is best to collect the sediment on a filter, and boil it in alcohol, whereby the hippuric acid is dissolved, and the uric acid left undissolved. By evaporation of the alcoholic solution the hippuric acid is obtained as crystals in an isolated state. Its nature may then be positively determined in the manner described in Section VII.

According to the investigations of Hallwachs and Wreden, the quantity of hippuric acid in human urine is much greater than is generally supposed. Its quantity according to Wreden exceeds even that of the phosphoric acid.

Wreden's volumetrical process is founded upon the fact, that neutral per-chloride of iron forms with a neutral solution of hippuric acid a precipitate which is insoluble in water, and invariable in its composition. This method however does not appear to yield trustworthy results.

The causes which determine the separation of hippuric acid as a sediment, are the same as those mentioned under the head of Uric Acid.

Indication.—Large deposits of hippuric acid occur in the urine of persons in perfect health who have indulged in large quantities of fruit, and particularly of the fruit of the prune (Duchek); and of bilberries, *Vaccinium Vitis Idæa*, and mulberries, *Rubus Chamæ-*

morus (Lücke); also after taking benzoic acid and cinnamic acid, which are in the body converted into hippuric acid, and as such separated from the urine.

The statement of Kühne, that after the ingestion of succinic acid a large quantity of hippuric acid appears in the urine, has not been confirmed by Hallwachs and Lücke.

When a large amount of hippuric acid is found in the urine of the sick, it is necessary, first of all, to inquire whether it depends upon any such cause, as the eating of fruit or the taking of benzoic acid. It is, however, certain, that hippuric acid may appear in the urine in large quantities, as the consequence of morbid states of the nutritive functions. Thus, hippuric acid has been found in large quantities in the urine in fever, being the chief cause of its acid reaction (Lehmann); it has also been found in diabetic urine, and in cases of St. Vitus's Dance, &c. The observations, however, hitherto made concerning the presence of hippuric acid in the urine of the sick, are still very defective, and yield no information of value either in the diagnosis, prognosis, or treatment of disease.

The opinion, that a tendency to the excessive formation of uric acid may be removed by the use of benzoic acid, in consequence of the uric acid in such case being replaced by the hippuric acid (Ure, Keller) has been shown to be erroneous. Benzoic acid, moreover, as a remedy in uric acid diathesis, is of no practical value.

SECTION C.

EARTHY PHOSPHATES.—PHOSPHATE OF LIME AND AMMONIO-PHOSPHATE OF MAGNESIA.

Earthy phosphates very frequently occur in urinary sediments, and chiefly in chronic diseases and in alkaline urine, the reverse of what happens in the case of uric acid sediments. They are always present when the urine is alkaline, whether it has become so naturally, or has been made so artificially by saturation of its free acid with an alkali, or an alkaline carbonate.

The mode of origin is thus explained:—when urine is rendered alkaline, through the formation of carbonate of ammonia, resulting from decomposition of urea (Section LXXXVII.), its phosphate of lime is thrown down, being soluble only in acid fluids; moreover, a triple phosphate—ammonio-phosphate of magnesia, which is insoluble in alkaline fluids, is separated, through the action of the ammonia on the phosphate of magnesia of the urine. Urine, with very rare exceptions, contains both phosphate of lime and phosphate of magnesia; consequently, the alkaline fermentation of the urine produces a sediment consisting of a mixture of both these phosphates.

This sediment, according to Neubauer's numerous investigations (*Journal f. Pract. Chemie*, vol. 57, p. 65) consists of 67 parts of phosphate of magnesia and 33 parts of phosphate of lime in 100 parts. (See Section CXXIII.)

An account of the microscopic and chemical characters of this sediment will be found in Section XXXIX. The triple phosphate has always a distinctly crystalline form; its crystal being usually well formed, somewhat of the shape of a coffin-lid. (*Plate II. Figs.* 3, 5, *and* 6.) When the urine is freshly passed, the crystals are less well formed, but they still present characteristic crystalline groups, closely resembling two fern leaves crossed at acute angles.

Phosphate of lime, on the other hand, usually presents an amorphous form under the microscope, consisting of ill-defined, highly translucent flakes, or of globular cells. The transparency of the phosphatic flakes is often so great, and their contour so little marked, that some little practice is required to recognise them under the microscope. This is the reason why such sediments so frequently seem to be formed solely of triple phosphates; whilst in reality they consist of two-thirds of triple phosphates, and one-third of phosphate of lime.

When the alkaline condition of the urine does not depend upon carbonate of ammonia, but upon carbonate of potash, soda, or some other fixed alkali, triple phosphates are not formed. In such case, the sediment appears to consist wholly of phosphate of lime.

Sometimes, however, crystalline deposits of phosphate of lime without triple phosphate are formed even in acid urine. (Dr. Hassall, "On the frequent occurrence of phosphate of lime in the crystalline form in human urine, and on its pathological importance." —Proceedings of the Royal Society, X. 38, 1860, p. 281.)

Indication.—The idea formerly held was, that sediments of the earthy phosphates were associated with an excess of the earths in the urine; and their presence was considered as indicative of the phosphatic diathesis. This, however, is a complete error, for alkaline, and especially ammoniacal urine, invariably throws down a sediment of earthy phosphates. Consequently, a sediment of this kind does not prove definitively the existence of an abnormally large amount of earthy phosphates in the urine. An increase of the earthy phosphates can only be proved by a quantitative analysis of the urine. (Section LXXI.) At most, we can do no more than give an approximative idea of the amount of phosphates from the quantity of the sediment, (see Section LXXXIII.); the process, however, there referred to, requires great practice, and is far from trustworthy.

Independently of this approximative calculation of the amount of earthy phosphates, these sediments afford the following practical hints:—

1. They are usually the first indications to the physician of the alkaline condition of the urine; pointing out to him the necessity for a further investigation into the cause exciting this condition. (Section LXXXVII.)

2. In cases in which sediments of earthy phosphates are passed with the urine, it is evident that they must have been formed within the urinary passages: consequently, there is reason to fear the formation of phosphatic calculi, if this condition continue for any length of time.

SECTION CI.

OXALATE OF LIME.

F. W. BENEKE.—On the Physiology and Pathology of Phosphate and Oxalate of Lime. *Göttingen*, 1850.

F. W. BENEKE—On the Origin of Oxaluria. *Göttingen*, 1852.

DR. JAMES BEGBIE.—On Stomach and Nervous Disorders as connected with the Oxalic Diathesis. *Edin. Month. Jl. Aug.* 1849.

CH. FRICK, of Baltimore.—Remarks on the Oxalate of Lime Diathesis and its Treatment. *Gazette des Hôpitaux*, Sep. 27th, 1849.

GALLOIS.—Essay on Oxalate of Lime in the sediment of Urine, in Gravel and in Calculi. *Gaz. Méd de Paris*, 1859, N. 35.

SMOLER.—Studies concerning Oxaluria. *Prager Vierteljahrschrift*, 1861.

Oxalate of lime is of particular interest as a sediment, being in this form much more easily and readily recognised by the aid of the microscope, than by chemical analysis. We shall therefore consider here the different phenomena which have been observed in connexion with its appearance in the urine.

A microscope of high power is requisite for the demonstration of the presence of oxalate of lime in the urine. The sediment, which it forms, is always crystalline, but the crystals are very minute, generally much smaller than blood- or pus-corpuscles. The form of the perfect crystal is always that of a rhombic-octohedron. (*Plate I. Fig.* 3.) The smallest, even under high powers, appear only as angular points.

On account of this minute size of the crystals, it is almost impossible to recognise an oxalate of lime sediment with the naked eye. Hence, whenever we suspect the presence of this sediment in the urine, it is advisable to filter the urine, remove the precipitate carefully from the moist filter, and place a little of it under the microscope. The practised eye will then at once recognise the oxalate of lime crystals, usually mingled with epithelium, mucus, and fragments of the fibres of the filter, and sometimes with other crystalline sediments, such as uric acid, &c. If the diagnosis is doubtful, we must resort to the other tests of the presence of oxalate of lime, described in Section XXXVIII.

We may in this way discover the smallest traces of oxalate of lime in the urine, which we cannot do, with certainty, by chemical tests.

Causes and indication.—The causes of the presence of oxalate of lime in the urine are to be sought in the following facts:—

1. Oxalic acid and oxalate of lime are constituents of several kinds of edible vegetables—rhubarb for example, common sorrel, the well-known fruit of *Solanum lycopersicum* (love-apple), &c. Oxalic acid and its salts are also sometimes used as therapeutical agents; and they are contained in the root of rhubarb, gentian, and saponaria, &c. Oxalic acid in this way finds entrance into the body, from which it is again separated in the urine, either wholly or in part as oxalate of lime.

2. Oxalic acid is also frequently formed by the decomposition of animal, vegetable, or mineral bodies. Thus, it is formed by the oxidation of uric acid, by the imperfect oxidation of sugar, starch, and salts of the vegetable acids: these salts through deficiency of

oxygen passing into the form of oxalates instead of carbonates. It is probable, moreover, that oxalates may be formed from salts of the carbonates and bicarbonates—the salts being deprived of a portion of their oxygen, and thus reduced to the condition of oxalates. In this way we can explain, in some degree, why oxalic acid is sometimes formed in the human body under favourable circumstances: thus, for instance, after the taking of carbonated drinks, of champagne and seltzer-water; when the respiration is impeded; or when an excessive quantity of sugar has been taken, &c. The special conditions, however, under which the formation takes place have not yet been discovered.

The question has often been asked: How comes it, that oxalate of lime which is nearly insoluble in aqueous fluids, passes through the walls of the renal capillaries into the urine? This question has not yet been satisfactorily answered. We may suppose, if we please, with C. Schmidt, that oxalate of lime forms a soluble compound with albumen, and passes in solution from the blood into the urine; the compound being then decomposed in the urinary passages, and oxalate of lime thus separated as a sediment. Or, again, we may suppose, that oxalic acid is first formed in the urinary passages, and in the manner already described, by decomposition of other substances; and when thus formed, unites with the lime, which is always present in urine. In this way, the oxalate of lime is formed within the urinary passages, or, under certain circumstances, even after the evacuation of the urine. Kletzinsky* has pointed out a third possible mode of its formation. Oxalic acid and lime, when brought into contact in a very dilute solution, do not immediately form an insoluble oxalate of lime; a certain time is required for their combination. Kletzinsky made the following observations on the subject. He added oxalate of ammonia to urine rendered strongly acid with acetic acid. The urine was then gradually passed through a four-fold filter, in fact, through four filters; and he found that a fine crystalline cloudiness of oxalate of lime was always formed after a short time in the clear filtrate, which had passed through the last of the filters. Moreover, he introduced the fluid above-mentioned into an endosmometer closed with an ox-bladder, which was then dipped in pure luke-warm water. In this case, he also found in the course of two hours crystals of oxalate of lime in the water outside the bladder. The salt of lime, together with the oxalate of ammonia, was here manifestly diffused through the animal membrane, the union of the oxalic acid with the lime having taken place outside the bladder.

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* Heller's Archiv, 1852, p. 207.

It is probable that oxalate of lime is formed in each of the three ways here described. It would be taking a partial view of the matter to suppose that its formation took place in one uniform manner only.

What indication, as regards *diagnosis*, *prognosis*, and *treatment*, does the presence of oxalate of lime in the urine afford?

In answering this question we must consider the subject under two heads:—

1. If the patient's urine invariably and for a long time—for weeks or months together—contains large quantities of oxalate of lime, his is a case of oxaluria—of the oxalic acid diathesis. This condition is one which always demands our serious attention, and for two particular reasons:

a. Because there are grounds for fearing the formation of oxalate of lime calculi—mulberry calculi—in the kidneys or the bladder;

b. And on account of the injurious effects which the oxalic acid has on the system generally. Oxalic acid, when taken internally in large quantities, acts like a poison, not only locally on the parts of the intestinal canal with which it comes in contact, but, generally, on the heart and nervous system. Hence we may conclude, theoretically, that a large formation of oxalic acid in the body would be productive of serious consequences. Many physicians, particularly in England and America (Prout, Begbie, Frick, and others), have observed and described such cases of oxaluria.

As little attention has hitherto been paid to the subject of oxaluria in Germany, I think it desirable to give here an outline of the very lucid description of this disease, as described by Dr. Begbie. He says:

There is a numerous class of patients, consisting of persons, for the most part, in the prime of life, and especially of the male sex; generally speaking, they are of the sanguineous or melancholic temperament, not accustomed to vigorous exertion, belonging mostly to the upper classes of society, and addicted to indulgence in the luxuries of life and good living. They suffer from indigestion in its mildest and severest forms. Frequently, they do not suffer from any manifest disorder, but complain merely of some slight inconvenience, resulting from imperfect digestion and defective assimilation—a feeling of weight and pressure at the pit of the stomach, together with flatulence and palpitations a few hours after eating. More serious symptoms, however, sometimes appear; these are not confined solely to the digestive apparatus, but appear also as affections of the nervous system, threatening even the mind. Patients, thus affected, are usually capricious, sensitive, and irritable, or dull, melancholic and despairing. They are continually plagued with a dread of some serious disease impending over them, such as consumption or disease of the heart. In milder forms of the affection, the patient exhibits the anxiety and general appearance of disturbed health—a loaded tongue, dry skin, and irritable pulse; but in inveterate cases, a dingy countenance, general wasting, falling off of the hair, a tendency to furuncles, carbuncles, psoriasis, and other skin diseases; dull deep-seated pains in the back and loins; intestinal and vesical hæmorrhage; incontinence of urine, and impotency. The affection may be slow of progress, and vary much in its consequences. Under the influence of proper diet, appropriate treatment, and country air, the disorder may be arrested, and even entirely removed. If, however, it be neglected, or badly treated, the affection will expose its victim to the dangers and sufferings attendant upon calculus in the kidney or the bladder, or even to the still more serious consequences, of malignant organic disease.

The cause of this affection is to be sought in the accumulation of oxalic acid in the blood. The poison is separated from the blood by the kidneys; and its separation in the form of oxalate of lime enables us to recognise the existence of the disease, and so by a simple and efficacious treatment to bring about its cure.

The following is the treatment laid down by Dr. Begbie for its cure: long persistence in a proper diet of flesh, milk, and mealy vegetables,—all saccharine matters being excluded; warm clothing, and luke-warm baths; as medicine, nitrate of potash, hydrochloric acid in doses of 20 drops 2 or 3 times a day, or in the following formula: ℞. Acid muriat. dil., Acidi nitrici dil., Syrupi aurantii, *aa* ℥ss, Aquæ ℥iss, of which one teaspoonful is to be taken in a wineglassful of water before meals.

Beneke describes the injurious influence of the oxalic acid on the body even more forcibly. He believes, that the phosphate of lime is thereby dissolved and removed from the body; and that in consequence of this deficiency of phosphate of lime the activity of the organic processes going on in the body, the cell-development, is diminished.

No distinct proof, however, has yet been given, that the symptoms, described above as belonging to the oxalic acid diathesis, do really depend upon the accumulation of oxalic acid in the blood; hence many observers, and amongst them Lehmann,* consider that the idea of an oxalic acid diathesis is incorrect. If, however, we recollect that oxalic acid undoubtedly possesses a poisonous influence on the body when given in large doses, and that every physician who has had much practice, has met with cases of the kind described by Dr. Begbie (I have met with several such myself), we must admit, that cases in which large quantities of oxalate of lime are passed for a length of time with the urine, should not be neglected by the physician. The causes of the discharge of oxalic acid should be carefully investigated—disturbances of the respiration with diminished absorption of oxygen, immoderate indulgence in sugar, disturbances of any of the secondary assimilative functions—and the treatment above-mentioned carried out.

2. All the cases, however, in which oxalate of lime is observed in the urine, cannot be classed under the category just described. Where only mere traces of this salt are found in the urine, or when large quantities of it are present, but yet only temporarily, as often happens in the course of certain acute and chronic disorders, we need not anticipate the dangerous consequences above referred to. The business of the physician is, in such cases, to investigate the cause of its occurrence—whether it proceeds from food or medicine containing oxalic acid; or whether its presence can be referred to any alterations of the nutritive functions of any part of the body. Prognosis in such cases is not very serious. But it is advisable, when we have discovered the cause of the abnormal condition, to encounter it at once by proper treatment.

SECTION CII.

CYSTINE.

A. Fabre.—*On Cystine,* &c., Paris, 1859.

Cystine is very rarely met with in the urine, and its practical signification is therefore comparatively of little importance. All we at present know on the subject is, that cystine is occasionally the cause of the formation of urinary calculi; in which case it always appears in the form of urinary sediment. Occasionally, however, cystine exists in solution in the urine.

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* Lehrbuch d. physiolog. Chemie. 2 Ed. v 1. p. 51.

Whether or not the formation of this substance is in any way injurious to the body through alterations produced by it in the intermediate stages of nutrition is uncertain. We know, however, that cystine may be constantly present in the urine for years without disturbing the health, although no cystine-calculus is formed.

For the means of recognising the presence of this substance in the urine by chemical and microscopic agencies, see Sect. XL.

We know nothing whatever of the causes which occasion its formation in the body. The large amount of sulphur which it contains—more than 26 per cent.—indicates its relation to taurine; hence, we may surmise, that the liver plays a part in its formation. Scherer has, in fact, found cystine in the liver, a proof that this substance, just like urea, uric acid, &c., is not formed in the kidneys, but elsewhere in the body, being taken up into the blood, and separated from it by the kidneys. Future investigations, we must hope, will explain to us the significance to be attached to the presence of cystine in the urine, and the more intimate conditions of its formation.

It is an interesting circumstance, that in the few cases in which cystine has been found in urinary calculi or sediments, it has been present in a large proportion of the cases in several members of the same family.

SECTION CIII.

XANTHINE—HYPOXANTHINE—GUANINE—GUANOXANTHINE—TYROSINE.

Strecker, *Annal. d. Chem. u. Phar.*, vol. cii. p. 108.
Städeler, *Annal. d. Chem. u. Pharm.*, vol. cxi. p. 28.
Scherer, *Annal. d. Chem. u. Pharm.*, vol. cxii. p. 257.

Xanthine has hitherto been very rarely found in human calculi; but it is occasionally met with as an urinary sediment. For its properties and tests, see Section V.

Hypoxanthine, guanine, and guanoxanthine are bodies closely allied to xanthine. They are present in small quantities in different organs of the body, in the spleen, the liver, and the pancreas, and probably sometimes also in the urine (Strecker). They must undoubtedly be regarded as products of the metamorphic processes. We know, however, so little of their origin and signification that we can do no more than refer to them here.

Tyrosine (compare Sections XXXIV. and XLI.) is a substance which results from the decomposition of proteine-matters. It has been found in different organs of the human body, generally associated with leucine; and in some rare cases as a urinary sediment. Its presence in any considerable quantity in the urine indicates the fact of alterations in the metamorphic processes, excessive decomposition of proteine-compounds, and is therefore of interest to the physician.

SECTION CIV.

B. ORGANIC SEDIMENTS—MUCUS AND EPITHELIUM.

Mucus and epithelium usually appear together in the urine as urinary sediments, and will therefore be here considered together. They are of much practical importance.

Urine, even in health, always contains a small quantity of mucus, which is derived from the mucous membrane of the urinary passages, particularly of the bladder and urethra. In women, mucus and epithelium of the vagina are not unfrequently mixed with the urine. The presence, therefore, of a small quantity of mucus in the urine has no pathological signification. The mucus usually appears in the form of a slight cloudiness, which gradually sinks in the fluid; it may be readily seen in urine collected in a glass.

The cloudiness increases with the abnormal increase of the mucus, and a slimy sediment is formed if the urine is left for some time at rest. With a little practice the observer may at once with the eye ascertain pretty accurately the amount of mucus present in the urine; in this way, indeed, he may, as a rule, obtain more accurate results than he can from complicated chemical processes, which, indeed, are not easily applied by the physician.

The tests for mucus will be found in Section XLII. Pure mucus forms a perfectly translucent mass, and is therefore scarcely to be recognised with the microscope; the epithelial cells, however, which are found mingled with it are readily known by their characteristic appearances. The mucus, when precipitated with alcohol or acids, is readily recognised as an indistinctly fibrillated mass. It is rendered more distinct by the addition of dilute tincture of iodine, which both precipitates and colours it.

By filtering the urine we obtain the mucus in the form of a tenacious mass, which has, when dried, a shining varnish-like appearance.

The microscope shows us that this mucous sediment of the urine frequently contains, in addition to the epithelium, several other foreign matters—spermatozoa, crystals of oxalate of lime, urates, and ammonio-phosphate of magnesia. Consequently, in all cases in which an accurate diagnosis is required, the mucus must be carefully examined with the microscope. The term mucus, chemically considered, is somewhat indefinite, as under this head are probably classed several modifications of proteine-matters, of fibrine, albumen, and caseine, &c.—which have not yet been carefully examined.

An increased amount of mucus in the urine has a double signification:

1. It points out, in the first place, the fact of an increase of the secretion of mucus from the urinary passages, a blennorrhœa of the bladder or the ureters. In women, as already indicated, we must satisfy ourselves that the mucus does not proceed from the vagina;

2. An increase of mucus in the urine encourages the acid and the alkaline fermentations of the urine so often spoken of. The alkaline —the conversion of the urea into carbonate of ammonia—is especially promoted by the presence of a large amount of mucus in the urine.

Further, we may observe, that pus-corpuscles in ammoniacal urine may be converted into a kind of jelly, which very closely resembles mucus. The physician frequently mistakes the slimy gelatinous mass thus formed for a mucous sediment. (See Section CV.).

SECTION CV.

Pus.

Test.—The microscope is always required for the diagnosis of pus in the urine. The pus-globules are known by their form and size, as well as by the characteristic nuclei which they present when treated

SECTION CVI.

CANCEROUS AND TUBERCULAR MATTERS IN THE URINE.

Cancerous and tubercular matters are sometimes met with, as sediments, in the urine. Their presence enables the physician to draw the important conclusion, that softening of a cancerous or tubercular deposit has taken place in some part of the urinary organs.

Cancer in the urine is usually found to be the product of cancer of the bladder, and more rarely of cancer of the kidneys. It is generally of the soft kind, encephaloid, and appears in the urine in the form of small masses—aggregates of cells, primitive and secondary—cells with thick walls, spindle-shaped, and caudate. In such case the urine, as a rule, also contains blood and blood-coagula.

Well-marked symptoms of disease of the bladder are always associated with cancer of the bladder: difficulty of micturition, and often symptoms also indicative of disease of the rectum, or of the vagina in women. In such cases the diagnosis is not difficult.

Cancer of the bladder is generally of the so-called villous kind, that is, it consists of compound-branched villi, which are sometimes hollow and formed of a fibrous stroma containing a deposit of [illegible] sometimes it consists of an amorphous mass with [illegible]. Hence the portions of the cancer which [illegible] separated from the bladder, and appear in the [illegible] of form. They are all of them, however, [illegible] and indicate with certainty the nature of the [illegible]

[illegible] represent some of the most characteristic [illegible] appear in urinary sediments. They are [illegible] work of Dr. Lambl, "*On Cancer of* [illegible] *Microscopical Diagnosis*" (*Prager* [illegible] 1856 [illegible] and partly from my own [illegible]

[illegible] represents a large fragment of villous cancer of the [illegible] as it appears under a low magnifying power [illegible]

[illegible] represents [illegible] portions of a villous cancer more [illegible] magnified [illegible]. The inner part consists of an amorphous fibrous structure containing numerous oval nuclei, and the outer part is covered with a compound layer of epithelial cells.

Pus from the parenchyma of the kidney is sometimes accompanied with scarcely any local symptoms, and consequently may be only discovered accidentally by the long-continued presence of pus in the urine.

Example.—A man, 36 years of age, was admitted into the Clinique at Giessen on account of a rheumatic-gastric fever. He recovered rapidly, and was on the point of leaving the hospital, when there suddenly appeared in his urine a tolerably abundant sediment, consisting of pus-corpuscles. The sediment remained for some weeks, the patient not experiencing the smallest difficulty in passing his water, nor in fact any symptom indicative of disease of the urinary organs. Subsequently pain was felt in the neighbourhood of the kidneys, accompanied with frequent shiverings. Typhus fever was epidemic at the time, and unexpectedly carried off the patient. On examination of the body, one of the kidneys was found almost in a complete state of suppuration. There was no other disease of the urinary organs.

In cases of this kind it is of importance that we should be able to decide whether the pus is the product simply of suppuration of the mucous membrane, catarrhal inflammation, or whether it is the result of more profound and extensive alterations of parts. The following facts will assist in deciding these points :—

The *duration* of the suppuration. The temporary presence of pus in the urine, for a few days only, always indicates that the supration is of a superficial kind.

The *condition* of the pus, as observed by the microscope. Perfectly normal corpuscles; round corpuscles, presenting their characteristic double and triple nuclei when treated with acetic acid, indicate laudable pus, and its origin from a simple catarrh of the mucous membrane. On the other hand, abnormal pus-corpuscles, of irregular forms and contours, producing irregular nucleated forms when treated with acetic acid; or an ill-defined granular mass, consisting of irregularly-shaped pus-corpuscles, and partially destroyed cells, indicate the probable existence of deep-seated suppuration, ulceration, or tubercular disease.

Various matters were formerly included under the head of pus; they were confounded with the pus, because without the aid of the microscope the eye could not with certainty distinguish them from pus. Of this class were cancerous and tubercular matter, and urinary casts.

hours, under the influence of air and light, of a dark brown porter-colour. On the addition of concentrated nitric acid, chromic acid and other oxidising substances it immediately assumed the dark colour. This condition of the urine was not observed in patients suffering from melanœmia alone, in the absence of melanotic cancer. Eiselt and Bolze consider that this peculiar condition of the urine will serve for the diagnosis of pigmentary cancer concealed within the body.

Tubercle in the urine, to the unaided eye, resembles pus; but may be distinguished from it by the microscope. It consists of irregular pus-corpuscles mixed with an ill-defined detritus, fragments of cells, imperfect nuclei, an indistinct and finely-granular mass with which crystals of cholesterine are sometimes mingled. The mucous membrane, or sub-mucous tissue, is the seat of the tubercular deposit, whence the urinary sediment of softened tubercle proceeds. The deposit may take place in the bladder, the ureters, or the pelves of the kidneys. In affections of this kind, which have lasted for a long time, the tubercular deposit generally spreads over the greater part of the mucous membrane of the urinary system, from the kidneys even into the bladder.

The following cases may serve to assist the observer in the diagnosis of tubercular deposit in the urinary organs.

1. A young man, 25 years old, came into my clinique for an affection of the bladder, which had troubled him for a year. The evacuation of the bladder was difficult and painful; the urine was sometimes bloody, and after standing, deposited a sediment, which contained blood-corpuscles, and pus-corpuscles partly normal and partly abnormal. (The pus-corpuscles were not round, but irregular; when treated with acetic acid, they either did not show their normal nuclei, or only showed small irregular nucleoli.) Besides this, the sediment contained an irregular amorphous granular matter, in part finely divided, and in part combined into larger masses, some of them as big as a pin's-head. Further investigation showed that the prostate was enlarged and very sensitive, and that the lungs were in an advanced stage of tubercular disease. The patient had never suffered from chancre or gonorrhœa. The diagnosis formed was tuberculosis of the bladder and prostate. The patient died from disease of the lungs, and the diagnosis was then confirmed by the autopsy.

2. A man, 30 years old, who had always been healthy, was

seized with attacks of pain, which passed from the region of the left kidney down to the bladder, and terminated with very urgent and frequent calls to micturition. These paroxysms lasted for several hours, and were followed by intervals of complete remission, lasting sometimes for days and sometimes for weeks. Half-a-year later a swelling formed in the left side of the scrotum; this broke and formed a fistula, which resisted all efforts to heal it. The urine contained neither gravel nor concretions, such as would lead to the suspicion of calculus of the kidney; after each attack, however, there was a slight sediment deposited, consisting of pus-corpuscles, which, as in the former cases, were of very irregular form, and when treated with acetic acid, presented no normal nuclei. Here, also, there was found, together with these corpuscles, an indistinct, amorphous, granular mass, of a kind such as is presented by tubercle-detritus under the microscope. This appearance, together with the affection of the testicle, indicated a deposit of tubercle in the left ureter.

SECTION CVII.

URINARY CYLINDERS AND TUBULAR CASTS.

Sediment consisting of urinary tubular casts and cylinders is of great practical importance in assisting us in the diagnosis of certain diseases of the kidneys. This sediment requires the microscope for its investigation. Its different forms and characters have been already described in Section XLV. We must, however, return to this subject, in order to explain the indications presented by the sediment under certain circumstances.

The sediment consists of long tubular or cylindrical bodies, which are formed in the tubuli uriniferi of the kidney, and chiefly in its medullary portion; these bodies take the form, more or less, of these canals, and to a certain extent form casts of them. The following are the chief forms under which the constituents of the sediment present themselves to us.

1. *Epithelial cylindrical casts.*—These consist of a mass of epithelial cells, exactly resembling those which are obtained from the section of the medullary portion of a fresh kidney, as observed under the microscope. (See *Plate I. Fig.* 4). The epithelium of the

tubules of Bellini is separated in adherent masses, during certain pathological processes, and evacuated with the urine. Single epithelial cylinders (caudate cells) are often also found in the sediment with these epithelial casts; they are derived from the calices or pelves of the kidneys (*Plate I. Fig.* 4). Sometimes also pus-corpuscles are present.

2. *Granular urinary casts* (*Plate I. Fig.* 6).—These are solid cylinders, resembling the last in form and size; they have, however, a fine granular appearance. Sometimes they enclose single epithelial cells, but more frequently blood-corpuscles, pus-corpuscles, as well as the different kinds of crystals met with in urine sediments, and especially oxalate of lime. Blood-corpuscles, pus-corpuscles, or granular cells are often found mingled with these casts in the sediment.

3. *Hyaline urinary casts* (*Plate I. Fig.* 5).—These, like the last, are solid cylinders, but so pale and translucent that it is often very difficult to distinguish them under the microscope, from the fluid which surrounds them. They are rendered more distinct by the addition to the urine of a small quantity of a solution of iodine in iodide of potassium, which imparts to them a brownish colour.

Between the casts described (2 and 3) there are several intermediate transition forms. The hyaline cylinders, for example, sometimes contain pus-corpuscles or granular molecules, or fatty and oily granules, and in such case they somewhat resemble the granular urinary casts.

Attention should also be paid to the diameter of these casts. Sometimes the diameter is small, $\frac{1}{100}$ of a line; sometimes it is equal to the $\frac{1}{50}$ of a line, or even more. Sometimes again, the casts are of unequal diameter, being small at one part, and at other parts broad, and varicose.

The casts and cylinders are sometimes present in the urine only in very small quantities. In such case, we must allow the urine to stand for some time before we examine the precipitate, or, what is better, filter the urine, and examine with the microscope the magma left on the filter. We cannot be sure that the urine does not contain casts, unless we do this. It is advisable, also, to colour the urine with a solution of iodine in iodide of potassium, in order not to overlook any of the transparent hyaline cylinders mentioned above. Sometimes forms are met with in the sediment, which have some kind of resemblance to, and may be mistaken for, granular cylinders, but yet are not granular cylinders. These forms are cylindrical and sausage-shaped, and consist of masses of fine molecules (*Plate II. Fig.* 2). They are most frequently met with in albuminous urine, or in urine which has stood for some time, and has undergone partial decomposition. They result from the precipitation in a fine granular form of albumen, mucus, &c. A practised eye will readily distinguish them from the true granular cylinder by their less regular shape.

Indication.—Urinary cylinders and tubes are always formed in the tubules of the kidneys, and most especially in the tubules of Bellini in the medullary portion of the kidneys. They indicate disease of the kidneys. They are usually regarded as a certain sign of the so-called Bright's disease of the kidneys, and in most cases really are so. The name, however, of morbus Brightii is somewhat indefinite, several different kinds of diseases of the parenchyma of the kidneys being usually included under the term. Something more definite is therefore required in considering these morbid products as indications in the diagnosis, prognosis, and treatment of kidney diseases. We will therefore endeavour to point out somewhat more distinctly the indications to be derived from the different forms of these products.

Urinary casts in the urine indicate that a separation of the epithelium of the tubules of Bellini is going on, desquamative nephritis. This process may be of a purely temporary character: consequently, urinary sediment which consists of epithelial cylinders, and disappears in the course of a few days, justifies a favourable prognosis. If pus-corpuscles are found mingled with the casts, the existence of acute inflammation (pyorrhœa) either of the kidneys, or of their calices, or pelves, is indicated.

On the other hand, granular and hyaline urinary cylinders always indicate a serious affection of the kidneys, generally of a chronic kind. The hyaline cylinders are probably formed by the coagulation of the fibrin of fibrinous exudation which has been thrown out in the urinary canals of the kidney (croupose inflammation). The granular cylinders are formed either through a further metamorphosis of the exudation in the urinary canals, or through the degeneration of the epithelial glandular cells lining the canals.

The larger the quantity of cylinders in the urine and the longer time they are present in the urine, the more extensive as a rule is the degeneration of the kidneys, and the more unfavourable, therefore, must be the prognosis.

If a large quantity of fatty particles be found embedded for a length of time in the cylinders, we may conclude, that the degeneration of the kidneys has taken the form of fatty metamorphosis.

The continual presence of blood with the cylinders, or of blood in the urine together with cylinders, indicates more especially disease of the vessels of the kidney—atheroma, fatty, or lardaceous degeneration of the renal arteries, particularly of the vascular loops in the Malpighian bodies.

Cylinders of very small diameter indicate a shrivelling and narrowing of the urinary canals of the kidney, and inordinately large cylinders, a widening of the canals. Cylinders of various diameters, with bulgings and contractions, indicate a varicose or distended condition of the canals.

When, as often happens, several of the modifications of the form of cylinders exist together, we may conclude that the pathological changes going on in the kidney are of a very complicated kind.

SECTION CVIII.

FUNGI.—INFUSORIA.—KIESTEIN.

DR. H. HASSALL.—On the development and signification of Vibrio lineala, Bodo urinarius, and on other fungoid products, &c., in urine.—*Lancet*, Nov. 1859, ii. 21.

Fungi and *Infusoria* never exist in fresh urine; their presence is accidental. They are, however, frequently found in urine which has been kept for some time, and are almost invariably present in urine which has undergone decomposition.

The *infusoria* are always very small; and with a sufficiently high power may be recognised by their motion. They consist either of point-like monads, or of long linear vibrios. More rarely, they are larger, roundish, and resemble mucus-cells. They are found chiefly in putrid urine, which contains albumen, mucus, blood or pus; and in some cases are so rapidly formed, as to lead to the idea that they were formed within the bladder. This fact is indicative of an inclination to the ready dissolution of the juices of the body, and may in some diseases of a septic nature be of service, s corroborative of an unfavourable prognosis. In all such cases, owever, the observer must satisfy himself, that the vibrios have ot been accidentally mixed with the urine.

Fungi appear in the urine in the form of roundish or oval cells spores and sporules), or of simple, or compound, or branched threads hallus, mycelium). As a rule, they do not appear in the urine ntil it has been kept for some length of time. The yeast-fungi und in diabetic urine are an exception; they appear in the form f oval cells, partly single, and partly joined together in pearl-like ows (*Plate II. Fig.* 2). They are spontaneously developed in dia-etic urine, especially during warm weather, often appearing soon fter the urine has been passed, and are thus of service in the diagnosis f glycosuria. They are not, however, of themselves, a sure sign of he presence of sugar in the urine.

L. Pasteur (*Comptes Rendus*, 1860, I. p. 841) rightly points out: hat the ova of these fungi and infusoria always pass into the urine rom without, and are never spontaneously developed in it (*generatio quivoca*); that in most cases they appear after the urine has been vacuated; and that they are the special cause of the acid and alka-ne fermentations of the urine, as well as of its putrefaction. Urine rom which these ova are carefully excluded may be preserved with-ut undergoing putrefaction.

Sarcinæ have also been sometimes found in the urine by some nglish physicians, as well as by Heller, Welcker, and Ph. Munk, n Germany (Section XLVII.). The sarcinæ in the urine afford no pecial indication, any more than they do when found in the other avities of the body, in the stomach, in the intestines, and the lungs, n which organs they are more frequently observed. They must be egarded as accidental parasites. Their presence in the bladder robably promotes the decomposition of the urine, rendering it alka-ne, and causing a deposit of earthy phosphates, &c.; it is there-re of practical interest.

Under this head may also be mentioned the so-called kiestein, hich was thought to be present in the urine of women only during regnancy, and therefore regarded as a sign of pregnancy. This ame was applied to a pellicle, which appeared on the surface of rine, that had stood for several days. The microscope shows us hat the pellicle in fact consists of very different elements, and for he most part of a large mass of vibrios with fungi, of crystals of mmonio-phosphate of magnesia, of fatty particles, &c. This pellicle, however, is not found exclusively in the urine of pregnant women; it is met with in women not pregnant, and also in men, and is therefore of no diagnostic value.

SECTION CIX.

SPERMATOZOA.

The presence of spermatozoa in the urine can only be shown with the microscope, and under a high power. They are readily recognised by their peculiar tadpole-like form. They are seldom present in large quantities in the urine; often, indeed, only a single one is found. It is necessary, therefore, to allow the urine to stand for some time in a champagne glass, then to pour off carefully the upper portion, and examine microscopically the lower portion, which will contain the spermatozoa, should any be present in the urine.

Their *indication* is evident enough. Their presence in the urine of man indicates that an emission of semen has taken place. Sometimes they lead to the discovery of onanism. In the urine of woman they prove that coitus has taken place, provided, of course, that there has been no accidental admixture of semen with the urine.

The imperfect spermatozoa (Section XLVI.) occasionally observed in the urine by Clemens (Henle and Pfeufer, *Zeitschrift*, 1846, vol. v. p. 133; and *Deutsche Klinik*, 1860, p. 30) indicate inordinate or long-continued irritation of the genital organs, whereby imperfectly as well as perfectly formed spermatozoa have been ejected. (Onanism, &c.)

SECOND PART.

QUANTITATIVE CHANGES IN THE URINE.

SECTION CX.

Much less attention has, up to a recent period, been paid to the quantitative alterations of the urine, that is to say, to the increase or diminution of its normal constituents, than to its qualitative alterations. The chemical character of diseases, and the changes of nutrition attending them were considered of little value in diagnosis. And besides this, the methods of analysis hitherto employed in such investigations were very difficult of application, tedious, and lengthy, requiring a complicated apparatus, and even, in some cases, a complete laboratory for their performance; so that they were available only in the hands of chemists.

By the recent introduction, however, of newer methods of investigation, and particularly of the method of volumetrical analysis, many of the processes have been much simplified, and may now in fact be readily performed by the physician. The necessity of a quantitative analysis of the products of the different metamorphic processes in the sick has become evident on account of its importance in the diagnosis, prognosis, and treatment of diseases. I trust, therefore, that the following attempt to bring the importance of these investigations under the notice of the physician, as far as it is possible to do so at the present time, may assist in bringing them into more general notice.

The quantitative alterations of the urine may be divided into two groups according as they are more or less readily investigated:

I. Into those which may be discovered without any minute chemical analysis, and which are of especial value to the physician on account of their being readily demonstrated;

II. And into those which require a quantitative chemical analysis, and are therefore more difficult of demonstration.

THE QUANTITATIVE ALTERATIONS OF THE URINE WHICH ARE EASILY DEMONSTRATED.

Under this head belong: the quantity of the urine; its solid residue and specific gravity; and its colour. These facts are so readily ascertained, require such simple apparatus, and so little time, that there is no excuse for omitting to obtain them in cases in which they may give an insight into diseased processes.

SECTION CXI.

THE QUANTITY OF THE URINE.

J. Vogel im Archiv für gemeinschaftliche Arbeiten, vol. i., p. 104.

The process required for determining the quantity of urine has already been described in Section L. The quantity is ascertained much more readily by measurement than by weight.

The estimation of the quantity of urine is of no use unless we also note the length of time during which it was passed. It is best to collect the urine which has been passed during the twenty-four hours, or during every hour, or at least to reckon the quantity passed during these periods. In accurately made investigations the physician must always take care that the whole of the urine is collected, and none of it lost during defecation or otherwise, and that no water has been accidentally poured into the urinal.

A simple estimate of the quantity of urine passed, without either weighing or measuring, sometimes gives important indications, but does not serve for accurate investigations. Graduated urine-glasses are readily obtained, and should always be employed; they enable the observer to ascertain the colour, the degree of transparency, the sediment, and other qualities of the urine much better than he could do if the urine were contained in a porcelain or earthenware vessel.

In order to ascertain the mean quantity of urine passed in the course of chronic diseases, we must not be satisfied with measuring the urine for a single day; for during that short period accidental circumstances may readily increase or diminish the quantity. The urine must be measured for several days consecutively, and the mean quantity then reckoned for twenty-four hours.

To ascertain the effect of any temporary influence over the secretion, it is best to calculate the quantity of urine passed per hour.

The estimation of the quantity of urine forms the basis for the quantitative determination of all the other constituents of the urine. It is also, in itself, often an important indication, showing the activity of the kidneys, and their power of separating water from the system.

It is often of importance to determine the relation of the quantity of urine to the amount of the pulmonary exhalation, the perspiration, and the fæces. Many hints for judging of diseased conditions of the body, as well as of their prognosis and treatment, may be thereby obtained. Thus, in most chest diseases, and heart and skin diseases, a diminution of the urinary secretion, associated with an increase of the pulmonary exhalation, is an unfavourable sign. The duty of the physician is, in such cases, to increase the urinary secretion in order to relieve the affected organs. On the other hand, in most diseases of the kidneys, the object is to diminish the action of the kidneys, and lessen the quantity of urine, by stimulating the other secretions.

In cases of permanent increase of the urine—polyuria, diabetes,—the determination of the quantity of urine is the first and most important means of ascertaining the nature of the disease.

To determine in any case whether the quantity of urine is increased or diminished, it is not enough to measure the urine; we must also ascertain to what amount the urine, thus measured, exceeds, or is less than the normal quantity. For this purpose, we must learn the normal quantity of urine passed by an individual. If very accurate results are required, as in physiological experiments concerning the influence of various agents on the urinary secretion, the normal quantity of the urine passed by the individual must always be ascertained at the time of each experiment. In the case of the sick, we must, as a rule, be satisfied with an approximative estimation, and substitute for the amount of urine of the individual, the mean general amount, which has been obtained by numerous experiments on different individuals.

In practice, however, little attention is paid to this principle. On the one hand, physicians are apt to trouble themselves too little with such investigations, and hence deduce from observations, correct enough in themselves, false conclusions, in consequence of judging them by an incorrect standard. Then, again, over-exact physiologists object to investigations of an approximative kind made on patients, because these investigations do not appear to them sufficiently accurate. It therefore seems desirable, that I should illustrate this subject by a few examples.

The mean quantity of urine passed in an hour by a healthy adult reaches, as we know, to from 60 to 70 C. C.; and may vary between 30 and 100 C. C. If then, we find, that in an individual, the normal amount of whose urine we are not acquainted with, a mean quantity of 80 C. C. are passed hourly under the influence of some medicinal agent, we may fairly conclude, that the medicine employed has a diuretic effect. The conclusion, however, is not certain, because, as we have seen, 80 C. C. are within the limits of the normal variation of the quantity of urine. Still less are we able, from this experiment, to decide to what amount the urine has been increased by the agent employed; because the normal amount of urine passed by the individual may be either somewhat above or below the mean quantity. To arrive, in such a case, at a trustworthy result, we must endeavour to obtain, by numerous observations, the mean quantity of urine passed by the individual at the time of the experiment, and then compare the quantity thus obtained with the quantity passed under the influence of the medicine.

If, again, we find, after numerous trials, that a person who has partaken largely of fluids, water, tea, &c., constantly passes an average quantity of 400 C. C. of urine per hour, we may be certain, without knowing the normal quantity of urine passed by the individual, that the drink taken has produced a diuretic effect. The 400 C.C. passed per hour exceed so much the general average quantity, that it becomes a matter of no importance whether the normal quantity passed by the individual is 40, 60, or 80 C. C. per hour.

The same thing often occurs in the case of the sick. The mean quantity of urine passed in 24 hours, by well-nourished healthy adults, varies between 1400 and 1600 C. C., and by others, who take less fluids, between 1200 and 1400 C. C. If then we find that a sick person passes only 400 C. C. in 24 hours, we may be sure that the normal quantity of his urine is materially diminished; the diminution is, inded, so considerable, that we gain nothing by ascertaining whether the individual normally passes 1200 or 1400 C. C. of urine. We may be equally certain that the urinary secretion is abnormally increased in a sick person, who passes 2500 or 3000 C. C. of urine in the 24 hours, although we have not accurately measured the normal quantity of urine passed by the individual.

Numerous observations show that, in healthy adults, the mean quantity of urine passed,

a. in 24 hours,

By well-nourished persons who drink freely, equals 1400 to 1600 C.C.
By those who drink less . . . . 1200 to 1400 C.C.

b. in one hour,

By free drinkers . . . . 50 to 70 C.C.
By less free drinkers . . . . 40 to 60 C.C.

If we calculate the mean quantity of urine by the weight of the body, we find that in an adult an average of 1 C. C. per hour is passed for every kilogramme (2 pounds) of the weight of his body.

Calculating according to the height of the body, we find, that an adult passes hourly an average of 40 C. C. of urine for each 100 centimetres of height.

The daily quantity varies between 1000 to 3000, and the hourly quantity between 20 and 200 C. C.

These variations depend in great part on different external influences, on eating, and especially on drinking, and on an increase or diminution of the perspiration, &c. In persons who live regularly, the variations are confined within much narrower limits than in those who live irregularly.

Moreover, we observe pretty regular variations in the quantity of urine passed at different times of the day. In Germany, the greatest average hourly quantity of urine is passed in the afternoon after dinner, viz., 77 C. C. in an hour; and the smallest quantity during the night, viz., 58 C. C. in the hour: a medium quantity is passed in the morning, viz., 69 C. C. We must, therefore, in all cases in which we wish to determine accurately the influence of any agent over the secretion of urine, take into consideration the period of the day when the experiment is performed.

It is very difficult to say what the agents are by which the quantity of the urine is increased or diminished, and chiefly because a large number of agents operate simultaneously on the urinary secretion, increasing and diminishing it, and thus aid or neutralise each other. Hence it is very difficult to determine the diuretic power of each agent separately.

The secretion of urine is undoubtedly increased by free drinking, although certainly not in the way pointed out by Falck, who affirms, that the whole of the water drunk is separated with the urine. We all know, that an individual who is exposed to a high temperature, if he drinks much and takes strong exercise, will perspire freely; and accurate experiments have shown, that under such circumstances, a larger portion of the water passes out of the body through the skin than through the kidneys. Fluids of the most varied kinds, such as water, carbonated water, beer, wine, tea, &c., when taken in sufficient quantity, act diuretically on persons in health, but not invariably so on the sick. The differences, however, which undoubtedly exist in the diuretic properties of different fluids are very difficult of determination, for numerous attendant circumstances modify their action, and so also do individual idiosyncrasies.

Examples.—The quantity of urine passed per hour in healthy men was increased by free drinking of water from between 60 and 70 C. C., up to 300, 400, 600 C. C., and even more.

In twelve students who, for the sake of experiment, drank large quantities of beer, the mean quantity of urine secreted per hour reached 473 C. C.; the minimum quantity being 212, and the maximum 838 C. C.

C. Westphal also (*Virchow's Archiv*, 1860, vol. xviii. p. 509) and K. H. Ferber (*Arch. d. Heilkunde*, 1860, I. p. 244) found, that the ingestion of water produces an increase of the urine in dogs as well as in man; the quantity of urine increasing gradually, remaining stationary for some hours, and then returning to the normal standard. They also found that the whole of the water imbibed was not evacuated with the urine; a considerable portion of it in fact passed off with the perspiration.

The secretion of urine is lessened by diminishing the quantity of drink, by abstinence from drink until great thirst is excited, but not in a degree equal to that in which it is increased by free drinking.

Example.—In four male persons of twenty to twenty-five years of age who were put upon a dry diet, the mean average quantity of urine, which under ordinary diet reached to about 86 C. C. per hour, was reduced to 37 C. C. (Mosler).

All causes which favour the separation of water from the body by other ways, diminish the secretion of urine; for example, free perspiration, copious watery stools, and frequent vomiting.

On the other hand, all causes which lessen the passage of water from the body through other outlets, increase the urinary secretion;

much moisture in the air, for instance, whereby the cutaneous and pulmonary exhalations are impeded, and other agents, such as cold, which diminishes the cutaneous perspiration.

As, however, causes of this kind seldom exercise an undivided influence over the urinary secretion, the quantity of urine which is noted in such cases can rarely ever be regarded as the effect produced by any one particular agent. For this reason I shall omit numerous examples, which I might quote under this head. To obtain some general idea of the actual power of these agents, the following considerations may be noted. The quantity of water passed with the urine is about equal to the whole quantity passed through the skin, the lungs, and with the fæces. The increase or the diminution, therefore, of any one of these last-mentioned functions must exercise a considerable influence over the amount of urinary secretion.

The action of the nervous system upon the functions of the kidneys has doubtless a very great influence over the quantity of urine. The action of the kidneys is generally increased by great bodily and mental exertion, and lessened during sleep, and when the body is at rest. It is also increased and diminished by different diseases.

A large number of observations made on seven men, gave 58 C. C. as the mean quantity of urine passed hourly during the night, and 73 C. C. as the average during the day. That rest alone was the cause of the difference in quantity which was passed during the night may be inferred from the fact that persons who work during the night, either bodily or mentally, pass as much urine then as they do during the day.

The influence of increased action of the kidneys on the secretion of urine is strikingly shown in cases of dropsy. For instance, in a dropsical patient who passes on an average only 400 C. C. of urine in twenty-four hours, the secretion under the influence of diuretics, or even by simple increase of the bodily powers, may reach, in a very short time, to 3000, and even 5000 C. C. per day; and this will happen without any material change in his mode of living, of the quantity of his drink, &c.

The following appear to be the simplest physiological conditions to which we must look as the regulators of the quantity of urine passed:

1. *The more or less watery condition of the blood.*—A large addition of fluid to the blood increases, and a large abstraction of fluid from it, diminishes the flow of urine;

2. *The state of activity of the kidneys.*—The action of the kidneys is not a simple force. It depends upon the degree of the pressure of blood in the renal arteries, and especially in the Malpighian bodies; upon the easy or impeded flow of urine from the urinary canals, upon the state of the nervous system generally, and of the nerves of the kidney in particular, &c. All these several forces, however, have not yet been clearly determined; we therefore class them all under the above general expression.

Quantity of urine passed by the sick.—The quantity of urine passed by the sick varies much. Its variations are in some cases accidental, depending upon different influences; in other cases they are constant, so as to be always essentially the same in diseases of the same kind. The abnormal states of the urine of the latter kind are of great importance to the physician, both in respect of diagnosis and prognosis, and treatment. The most important of these are the following:—

1. In all febrile diseases during their acute periods, the quantity of urine is considerably diminished, but increases again when the intensity of the disease has passed. (Among the very few exceptions to this rule may be mentioned intermittent fevers during their paroxysms.) During convalescence the quantity of urine again becomes normal, or even exceeds the normal quantity.

Hence, in all such diseases, the quantity of urine, especially in conjunction with the colour of the urine (Section CXIII.), gives us important indications. Thus a constant daily diminution of the quantity of urine indicates, that the intensity of the disease is increasing; the continued passing of a diminished amount of urine—less than 800 C.C. a-day—that the intensity of the disease has not diminished; on the other hand, a gradual increase of the quantity of urine shows that the force of the disease is broken.

An explanation of this general law, which is of considerable importance as indicating the state of the nutritive functions of the body in febrile diseases, can scarcely yet be given. It would appear, on close examination of the urine, that in all these cases the diminution of the quantity of urine depends solely upon a diminution of the quantity of water separated by the kidneys. How this is brought about, whether by diminution of the pressure of the blood, or by lessening of the nervous influence, &c., has not yet been ascertained.

Diminution of the quantity of urine occurs, with very few exceptions, in all acute febrile diseases, in pneumonia, pleurisy, typhus rheumatic, gastric, and pyæmic fevers, &c. The fact is well known to all physicians, and requires no illustration here. The following cases serve to show the changes in the urinary secretions in these diseases:—

An attendant in my clinique, the normal quantity of whose urine had been for some time previously determined, fell ill of typhus. The daily quantity of urine, which he had previously passed was on an average about 1800 C. C., it now gradually diminished, and in the course of three days fell down to 200 C. C. In the five following days the quantity again gradually increased up to the normal standard; then exceeded this, reaching to 2200 C. C., and finally again came down to the normal amount.

In a patient suffering from pneumonia the urine first diminished to 500 C. C.; in the course of ten days increased to the normal amount; then exceeded this, reaching to 3000 C. C.; and lastly, with slight variations, gradually returned to the normal quantity.

2. Towards the fatal termination of diseases, acute as well as chronic, the urine in most cases either gradually diminishes, or remains at a low standard, varying somewhat from time to time. But this is not always the case. Sometimes the urine diminishes only very slightly up to the time of the death of the patient, amounting to as much or more than 800 C. C. a-day. This doubtless depends upon the circumstance, that in many cases the immediate cause of death is to be referred to a gradual failing of the nutritive powers; whilst in other cases, it is rapidly induced by disturbances of the nervous system, impediments to the heart and lungs, &c.

3. The quantity of urine passed in chronic diseases, is of especial interest to the physician, in dropsy for example, and in those disorders to which the generic name of diabetes is usually given.

The quantity of the urine, and especially of the water secreted by the kidneys, is generally much diminished in cases of dropsy. In consequence of this, the constituents of it, and especially the water, which should otherwise be evacuated, are retained in the blood; thereby favouring the exudation of the dropsical fluid into the areolar tissues, into serous cavities, &c., and rendering still more difficult the absorption of the fluid already effused. Long experience has shown, that the cure of the dropsical is especially promoted by increasing the discharge of urine by diuretics. The quantity of urine passed by the dropsical is the surest sign on which to form a prognosis, and also gives us the best indication for treatment.

We usually designate with the name of diabetes those diseases, in which the quantity of urine for a length of time exceeds constantly and considerably the normal standard. To judge of these cases, however, it is necessary to ascertain the amount of solid constituents contained in the urine; it is not enough merely to measure the amount of fluid passed. (Section CXII.)

4. It is evident, that in the sick the state of all those forces, which influence the secretion of the urine in health, must be taken into consideration. In the sick, for instance, free drinking, and a watery state of the blood, combined with increased activity of the urinary organs, may temporarily increase the quantity of urine. Generally speaking the urine is diminished temporarily, through sweatings, diarrhœa, and other watery evacuations; and as a rule permanently, in consequence of the sick taking less food than the healthy, and because in them the nutritive powers are generally enfeebled.

SECTION CXII.

Solid Residue and Specific Gravity of the Urine.

J. Vogel. *Archiv für gemeinschaftl. Arbeiten,* vol. i. p. 119.

1. The method for estimating the quantity of solid residue of the urine, as well of its water and other constituents, which volatilise at a temperature of 100° C. (212° Fahr.) has been already described in Section LII. The processes, however, there given are both tedious and difficult, and therefore of little practical utility. They must, nevertheless, be resorted to in all cases in which an accurate estimation of the quantity of the water and of the solid residue is required.

For the purposes of the physician, who only requires approximative results, these processes may be advantageously passed over; the solid contents of the urine being estimated by its specific gravity. The method for taking the specific gravity of the urine is described in Section LI. The urinometer, with the glass apparatus belonging to it, is the most convenient instrument for the purpose.

If the urine, independently of the variations of its watery part, invariably contained the same relative amount of constituents, we should be able from its specific gravity to determine accurately its amount of solid constituents, just as we determine the percentage of alcohol in spirits, or the strength of sulphuric acid, &c. But this unfortunately is not the case. The quantity of different constituents of the urine increases and diminishes in very varying proportions; consequently we cannot obtain accurate results as to the solid constituents of the urine from its specific gravity. The best formula by which to reckon the amount of solid contents of the urine from its specific gravity is Trapp's. It consists in doubling the two last figures of the specific gravity which is obtained. The product gives the number of grammes of solid constituents in 1000 grammes. Thus urine of a specific gravity of 1·010 should contain in 1000 grammes, 20 grammes of solid constituents; of a specific gravity of 1·015, 30 grammes; of 1·020, 40 grammes, and so on.

In order not to draw erroneous conclusions as to the amount of solid constituents in the urine, through judging by its specific gravity, we must keep in mind the amount of error to which this method is liable. Numerous experiments made by myself, as well as the observations of others, show, that by this method we may be led into an error of $\frac{1}{10}$ or even of $\frac{1}{7}$; and that in the case of the sick, especially when their urine has a high specific gravity, the error may be even greater, amounting to $\frac{1}{5}$ and even to $\frac{1}{4}$. If, again, the urine of a sick person yields, on three consecutive days, 55, 50, and 60 grammes of solid constituents, according to Trapp's formula, we should not be justified in saying, that on the day when the formula gave 60 grammes he passed the largest quantity of solid constituents in the urine, nor that on the day when it gave 50 grammes he passed the smallest quantity. The difference in these three numbers is so small, that it may be fairly considered as a possible error of observation. In cases of this kind, in order to arrive at any positive conclusion as to the amount of solid constituents in the urine, we must resort to some more exact method—to evaporation, for example.

On the other hand, if we find, from the specific gravity of the urine, that a person, who has been accustomed to pass a daily average of about 60 grammes of solid constituents in it, secretes on a certain day only 30 grammes, we are justified in concluding that he passed on that day a much less quantity of solid constituents than ordinary; for in such case the difference is too great to be accounted for by any possible error of observation. Still, however, to affirm, that the person had on that day passed only half the usual amount of solid constituents in his urine, would be rash and unwarrantable, for by direct experiment we might perhaps find 28 or 36 grammes instead of 30.

As the estimation, by its specific gravity, of the solid constituents of the urine gives such very inexact results, it seems immaterial whether we make use of Trapp's coefficient 2, or of any other—of Häser's, for instance, 2·33, for the difference between these two, which only amounts to $\frac{1}{6}$, would still fall within the limits of unavoidable errors of observation.

W. Kaupp (*Archiv. f. physiolog. Heilkunde,* 1856, part 4) also found Trapp's formula correct. The recent researches of Neubauer, however (compare p. 156, and p. 268), tell rather in favour of Häser's formula. The coefficient 2, by its simplicity, and by the readiness with which it allows the calculation to be made mentally, recommends itself to us in the estimations and calculations made at the bedside of the patient, which never can be very accurate. In cases of this kind differences in temperature of the urine, if they do not exceed two degrees, may be disregarded.

2. What practical conclusions can the physician draw from a knowledge of the quantity of solid residue, and of the specific gravity of the urine?

First of all, from the specific gravity we are enabled to calculate the weight of a measured quantity of urine. The calculation is simple enough: 1000 C.C. of urine of sp. gr. 1·024 weigh 1·024 grammes, and so on.

Then, again, the specific gravity of the urine, and the quantity of solid constituents as thereby calculated, or as ascertained by direct experiment, often give us important indications concerning the quantitative changes going on in the nutrition of the body, and particularly concerning the quantity of solid parts and of water, which have been separated through the urine under certain conditions and in a certain time.

the separation of morbid products from the body being thereby favoured, as happens in many cases of hydræmia and dropsy. This form of increase of the urinary secretion (hydruria) is therefore totally different from the diabetic form.

Examples.—A woman, 31 years of age, who had long suffered from symptoms of anæmia and hysteria, with giddiness, headache, spasms of the cervical muscles, hyperæsthesia of several of the vertebræ, pale face, &c., passed an exceedingly large amount of urine, the daily average, as calculated from fourteen days' observation, amounting to 3,080 C.C. The specific gravity of the urine was not much less than natural, but the amount of solid constituents in it, according to calculation, reached an average of 87 grammes daily, a quantity much greater than normal. The maximum quantity passed in 24 hours was 136 grammes, which is more than double the normal quantity. In this case, which was one of true diabetes insipidus, the increased separation of solid constituents combined with deficiency of nourishment, was, manifestly, the chief cause of the symptoms. She soon improved in health under a generous diet, with steel, and other tonics.

A man, 35 years old, of Herculean frame of body, suffering from rheumatism of the neck, passed a very large quantity of urine, the daily average of twenty-four observations being 2983 C.C. Its specific gravity, however, was very low, being between 1·005 and 1·012; and the average quantity of solid constituents less than normal, amounting only to 42 grammes. The man did not appear to suffer in any way through the increased secretion of urine, and his case was evidently one of simple hydruria, not of diabetes.

Many other deductions concerning the quantitative relations of the nutritive materials of the body in disease may be drawn from the specific gravity of the urine, and from the amount of its solid constituents. These will naturally present themselves to the mind of the physician. Thus, for instance, the relation of the solid constituents, which are separated with the urine, may be compared with the quantity of matters which are separated through the skin and the lungs; and when the quantity of solid matters taken with the food is measured at the same time, we obtain the relative quantity of materials taken into the body, and separated from it. A knowledge of all these facts is of great importance in reference to the nutritive changes going on in disease; and the means for arriving at them are of a kind which are capable of being readily introduced into every clinique. So little, however, has as yet been done in this field of observation, that no positive conclusions have been at present arrived at in relation to them.

The specific gravity of the urine, also, gives the physician indications, which though of themselves not sufficient to lead to any distinct conclusions in diagnosis, prognosis, or treatment, are nevertheless of service in leading to further investigations. The following considerations may be placed under this head:—

Urea is the chief solid constituent of the urine. It generally equals in quantity all the other solid constituents of the urine together, and sometimes exceeds them. Consequently, the specific gravity of the urine may serve to point out approximatively the quantity of urea in it. Such a mode of determining the quantity of urea is, however, very uncertain, and will never replace the direct method of estimating it, which is readily performed.

When the quantity of the urine is much less than normal, and its specific gravity is high, we may usually conclude, in the case of healthy people, that its condition has been caused by abstinence from drink, or by increased perspiration, and in the case of the sick by acute disease. When the urine is much greater than normal and of low specific gravity, we may conclude that a large quantity of watery fluid has been taken. In the sick, who are suffering from hydræmia or dropsy, urine of this kind is a favourable sign, and shows that the system is making an effort to get rid of the superabundant water collected in the blood or in the tissues.

If urine is passed in large quantities, and has a high or even its ordinary specific gravity, we must test it for sugar: if there be no sugar in it, the case is one of diabetes insipidus.

If the quantity of urine is not increased, or if it is diminished, and yet its specific gravity is low, we may suspect the existence of an impediment to the secretion of urea, and in such a case must fear the occurrences of those symptoms which result from the retention of urea in the body (uræmia).

The solid residue of the urine is diminished in most chronic diseases, excepting diabetes. An increase of the residue indicates a more active condition of nutrition, and is therefore a favourable sign.

On the other hand, an increase of the solid constituents of the urine in acute diseases, when at their height, is an unfavourable sign, because the inanition which always accompanies such cases is thereby increased and favoured.

The specific gravity of the urine as a rule in acute febrile diseases stands in a direct [illegible] to that of its quantity. The specific gravity, it [illegible] the [illegible] of the [illegible] in proportion as the quantity of the urine diminishes [illegible] with the increase of the urine and during convalescence often sinks below the normal. We must be very cautious in founding any differential diagnosis upon mere observation of the specific gravity of the urine in diseases which in other respects present a similar train of symptoms.

Thus in typhus it has been stated that the specific gravity of the urine increases in a less degree than in other acute, and especially inflammatory diseases; and that in fact in the essentially typhous period of the disease the specific gravity was only [illegible], whilst in acute affections of the brain and meninges from the beginning to the end it was as high as from [illegible] to [illegible]. Hence this difference in specific gravity has been used as a means of diagnosis in those cases occasionally met with in which it is difficult to distinguish between typhus and acute affections of the brain.—A. Ziegler. [illegible] Erlangen. [illegible], p. 9.

The idea of our being able to distinguish diseases by one single phenomenon, and one which in comparison with the other symptoms appears very unimportant, we must ascribe to the now happily admitted [illegible] method of comprehending diseases. By this method of [illegible] diseased processes, just as in the [illegible] species the external appearances [illegible] instead of [illegible] their causes and [illegible] in view. [illegible] of such a kind [illegible] symptom of disease [illegible] by numerous [illegible] symptom and its [illegible] to some degree explained, and its necessary [illegible] disease demonstrated.

[illegible] is not only wanting a satisfactory [illegible] of the specific gravity of the urine in typhus, but the very fact itself may be doubted as being true in all cases. I can only speak of it as true in some solitary instances. At least in the observations which I have made of the urine in typhus cases where there was a high degree of fever and a certain degree of reaction present, I found at the acme of the disease, that the specific gravity of the urine was high, as the following cases show:

(The figures in all cases indicate the specific gravity of the whole quantity of the urine passed in 24 hours during the height of the disease. The frequent blanks which appear, result from the circumstance that it was not always possible to collect the whole of the patients' urine free from fæces, on account of its being often passed involuntarily with the fæces, a circumstance which frequently renders an exact quantitative analysis of the urine in typhus very difficult, and indeed almost impossible;)

Case 1.—3rd day, 1·019—1·029—1·031—1·026—1·024—2 days omitted—1·019—1·021—1·016. Subsidence of the fever. Convalescence.

Case 2.—4th day, 1·028—1·029—1·027—1 day omitted—1·028—1·027. Death.

Case 3.—2nd week, 1·019—1·020—1·018—1·020—1·022—1·026. Slow convalescence.

The specific gravity of the urine in typhus, as in other acute diseases, falls as the fever departs and convalescence arrives.

On the other hand, I must admit, that there are cases of typhus in which the specific gravity of the urine even during the height of the disease is low, and even less than normal. The following are examples of this:—

Case 1.—1·008—1·014—1·017—2 days omitted—1·017—1·027—1·015—1·014—1·015—1·014—1·012. Death.

Case 2.—1st week, 1·018 to 1·020. 2nd week, 1·012 to 1·015. Then convalescence.

Case 3.—1·021—1·020—1·015—1·014—1·010—1·006—1·010—1·012—1·013—1·015—1·011. Convalescence.

In all these cases the fever, from the beginning, had a distinctly marked adynamic character, and the general condition of the patients, especially the weak and distinctly double-pulse, afforded much more trustworthy signs whereby to distinguish the case from one of inflammatory affection of the brain, and its membranes, than the specific gravity of the urine, which, moreover, I have not always found so remarkably high in meningitis as Ziegler states it to be. Besides this, diminution of the specific gravity of the urine occurs in other forms of fever, as well as in typhus, when they assume a well-marked adynamic type, as in pyæmia, putrid fevers, &c.

SECTION CXIII.

QUANTITY OF THE PIGMENT-MATTER OF THE URINE.

J. VOGEL, *Archiv für gemeinschaftl. Arbeiten*, vol. i. p. 137.

The colour of the urine and its pigment matters have been already spoken of on different occasions. (Sections IX. and LIV.) It is very difficult, indeed almost impossible, to obtain an accurate estimation of the quantity of pigment-matter in the urine, such as we are accustomed to expect at the present day from quantitative chemical analysis. I have, therefore, proposed a method, which is much more simple and easy, for estimating the colouring-matter, and which may be practised by the physician. This method, it is true, gives only approximative results, but it affords us interesting and valuable conclusions, which may be applied in diagnosis, prognosis, and treatment.

This method, and the mode of employing it, has already been described in Section LIV.; by means of the gradations of colours given in the Table IV., anyone can make use of it.

As objections of different kinds have been made to this method, I will here shortly answer them:—

First of all, it has been objected, that the colour of the urine does not depend upon any one single body, but upon several different pigment-matters. This is true enough, and has been already admitted. (Section LXXXIV). But the abnormal colours of the urine, whether accidental, as when caused by rhubarb, senna, &c., or whether depending upon bile-pigment, uroxanthine, uroglaucine, urrhodine and uroerythine, are comparatively rare, and, when present, may be readily recognised. In all such cases it would, doubtless, be a mistake to make use of the table of colours for the quantitative estimation of the pigment-matter. No fair exception, however, can be taken to the method because it is not applicable in such exceptional cases; it very rarely indeed happens, in any quantitative chemical investigation, that a method is applicable in every possible case. In by far the greater number of cases the urine, especially when filtered, contains either none, or only a very small quantity, of such abnormal colouring-matters; being in most cases coloured chiefly by the ordinary colouring-matter, Heller's urophæine.

Moreover, it has been objected, that the shades of colour given in table of colours do not run in a regular series, and that through tion of brown or of very high-coloured urine, for instance, we ould not obtain exactly the same shades of colour as pale urine yields; nd consequently, that the statement, that red urine contains 32 es more, and brownish-red urine 64 times more colouring-matter, an pale yellow, is not sufficiently accurate. I am quite willing to mit, that the colouring-matter of the urine is not invariably the ame under all circumstances, but that it may present modifications, hich exercise an influence both over its colouring power, and over he particular shade of colour produced by it; but this is no reason hy we should not use the colour of the urine for the approximative stimation of its pigment-matter, taking care not to fix the limits of ossible errors too low.

Hitherto, notwithstanding the praiseworthy labours of Scherer and Harley, we have not been able to obtain the colouring-matter of the urine in a pure state, and consequently the fixing of the limits of error in this case is completely arbitrary. I believe, however, that I am rather above than below the mark, if I assume, that the possible error may exceed by ¼ or even ⅓ the number found. Variations, therefore, which exceed these, indicate with certainty a difference in the amount of colouring-matter in two kinds of urine when compared together; whilst other variations, which are less than these, may be considered as of no value.

If, for example, the quantity of pigment-matter, which a healthy person passes in 24 hours, amounts to 4, and we find that a sick person passes from 16 to 20, we may be sure that there is a considerable increase of the pigment-matter in this case, to the extent of at least 2 or 3 times the normal amount. So, also, we may be sure that the quantity is abnormally diminished, if the calculation only gives 1. But if the quantity is found to amount to 3·5 or 4·5, we cannot conclude with any certainty either as to its increase or diminution.

For these reasons I consider I am right in maintaining, that useful information may be obtained from this method, provided it be cautiously applied; and that, if the hypothesis here used as a ground of explanation of its signification be correct, it may yield important explanations of the nutritive processes—of the destruction of the blood-corpuscles—explanations of still greater value, because the means which the physician possesses, of forming an opinion as to the extent of this part of the nutritive function in the sick, is very limited.

The *indication* afforded by an increase or a diminution of the pigment-matter of the urine may be derived from the following considerations, which are indeed in part only hypothetical, but still, very probably, correct.

There are many grounds for believing, that a portion of the blood-corpuscles undergo a retrograde metamorphosis in the living body, and are dissolved; and that their colouring-matter, hæmatine, is thereby changed, and at last separated from the body in the form of the pigment-matters of the urine and bile. Consequently, we may obtain from the amount of these matters taken together, a sort of measure of the degree of decomposition of the blood-corpuscles, which is going on. Useful hints and conclusions respecting the diagnosis, prognosis, and treatment of many diseases may be gained in this way.

We are not yet able to determine what amount of blood-corpuscles, or hæmatine, corresponds with a given quantity of urine-pigment; although I have often compared the colouring power of a known quantity of urine-pigment, as pure as possible,—and for which I have to thank Dr. Harley,—with that of a known quantity of blood-corpuscles. We know too little at present of the changes which the hæmatine undergoes before it is converted into urine-pigment. For this reason I have proposed as a standard for ascertaining the quantity of urine-pigment, to fix at 1 the quantity of urine-pigment contained in 1000 C. C. of pale-yellow urine, instead of attempting to measure the absolute quantity of urine-pigment by weighing, or by comparing it with the colour of a known quantity of blood-corpuscles—such means of estimating the pigment being difficult.

The following are the arguments upon which the above hypothesis: viz., that the urine-pigment and bile-pigment are modifications of the colouring-matter of the blood, is founded:—

Blood-colouring matter is destroyed with difficulty. Extravasations of blood in the body, as well as blood that has been subjected to various influences out of the body, retain their colour with great tenacity, or only undergo slight modifications of colour. Consequently, it is not probable that the colouring-matter of blood, which has been used, and become useless for the purposes of life, passes out of the body as a colourless compound; but, on the contrary, there can be no doubt that it still retains some of its colour when excreted. As, moreover, the only coloured excretions of the body are the urine and fæces; we must consider the urine-pigment, or the bile-pigment (as modified in the fæces), or both of them, as formed of the used-up colouring-matter of the blood. For such reasons, many excellent observers, Scherer, Polli, Virchow, and Harley, have concluded that the bile-pigment, and the urine-pigment, or both of them, are, in part, educts of the hæmatine. Harley, moreover, has lately shown that the very pure urine-pigment prepared by him closely resembles, in many respects, the colouring-matter of the blood.

The quantity of urine-pigment normally passed by a grown-up person, amounts, in 24 hours, to from 3 to 6, or, on an average, to about 4·8 or 0·2 per hour—1, as above mentioned, being taken as the standard.*

By means of this standard we judge of the quantity of pigment in the urine in a case of disease, whether it be normal or increased, or diminished.

The quantity of urine pigment is considerably increased in all acute febrile diseases, although the urine itself is diminished; in such cases it reaches 16, 20, and even more. The increase is still greater in fevers, during whose progress the blood undergoes dissolution (typhus, septic fevers).

We notice, indeed, as a general consequence of these diseases, a diminution of the blood-corpuscles, and a more or less well-marked anæmic (oligocythæmic) condition of the body.

Examples.—The quantity of urine-pigment in a large number of cases of pneumonia varied between 16 and 24 during the height of the fever. In a case of acute rheumatism, when the disease was at its height, it reached from 30 to 32; in a man suffering from typhus, during several days, to between 80 and 100; in a man, who had inhaled arseniuretted hydrogen, to between 600 and 800! In the last case, however, the matter which coloured the urine differed from the ordinary urine-pigment, being nearly pure hæmatine; and hence the quantitative analysis of the colouring-matter, as measured by the depth of colour of the urine, can only be considered as approximative;—the difference, however, between the quantity found in these cases and in normal conditions is so great, that any possible error of ¼, or even of ⅓, need not be taken into consideration here.

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* My observations show, that the quantity of colouring-matter passed with the urine varies greatly. I found, during the 24 hours, 8 to 30 parts of colouring-matter according to the above scale.

On the other hand, the quantity of urine-pigment is decidedly less than normal in many cases of disease: in those cases, for instance, in which there is a diminished formation of blood-corpuscles, as in chlorosis and anæmia; in convalescence from severe diseases; in hysteria and nervous diseases, &c. In cases of this kind, the condition of the urine often serves as an aid to diagnosis and treatment,—the use of tonics, and especially of iron, being indicated.

Examples.—The daily quantity of urine-pigment in chlorotic persons was frequently found under 1; and in convalescence, after severe diseases, for a long time often not more than from 1 to 2, &c.

SECTION CXIV.

Quantitative Alterations of the Urine, requiring complicated Chemical Operations for their Demonstration.

The quantitative alterations of the urine considered in the foregoing Sections are very easily made out. Their estimation, in fact, requires but little practice, special knowledge, and apparatus; so that the physician may himself undertake the investigation in all cases of disease in which the determination of these changes is a matter of importance.

The quantitative alterations in the composition of the urine now to be spoken of have, on the other hand, been hitherto much more difficult of determination. They required, as a rule, more time than the physician could give to them, besides special chemical knowledge, and a certain amount of practice in quantitative chemical analysis; and, moreover, some of these processes could not be carried out correctly except in a well-furnished laboratory. Consequently, analyses of this kind have hitherto been undertaken almost solely by chemists for the solution of physiological questions, and rarely ever employed for practical purposes by the physician. Investigations of this kind have not, generally speaking, been regarded as necessary, or as capable of yielding any important information concerning the nature, &c., of diseases; but have been looked upon rather as superfluous and useless.

Under these circumstances, it was useless to expect that physicians would undertake such investigations; though some few, it is true, have entered on the task, partly from love of science, and partly because they thought thereby to render important services to their patients.

Happily, however, this state of things now no longer exists. In consequence of the extensive application of chemistry to the arts and manufactures, new methods have been discovered whereby quantitative chemical analyses have been much simplified. These methods, and especially volumetrical analysis, are peculiarly adapted for the purposes of the physician, and particularly for the quantitative investigation of the urine. This simplified method of analysis may be accepted as perfectly accurate in respect to several constituents of the urine; and we may expect that it will also soon become so in all the others.

Most of the quantitative analyses of the urine, which a few years ago were difficult of performance, have in this way been so simplified, that any properly educated physician may readily undertake them. Loss of time in their performance, moreover, forms no excuse for the physician, in cases in which the investigation is required, for a chemist may always be found ready, for a moderate consideration, to undertake the simplified analysis; and, if necessary, any intelligent attendant, or servant, provided he be careful, may, as I know from experience, be taught enough for the purpose in a very short time.

The chief point for the consideration of the physician who undertakes such analyses is, that he should always clearly understand the object which he has in view. If he is not clear upon this point, he had better not undertake the investigation, for in such case the analysis is generally useless, and very often, indeed, productive of mischief. My chief object in the following sections will be to instruct the physician upon these points as far as it is possible to do so at the present moment.

I must, however, first premise certain general rules for the special investigation of the single constituents of the urine. These rules are given in the following Section.

uble and cost of the analysis are completely thrown away. In me cases, especially in the sick, the determination of the quantity of rine passed in a given time is often difficult; sometimes the time is ot accurately kept; more frequently a certain quantity of the urine lost with the motions or passed involuntarily; and frequently it is arelessly thrown away or mixed with the other matters by the urses during the absence of the physician. He must, therefore, be prepared for and guard against these different sources of error, and in those cases where he feels that he is not safe from error, he had better refrain altogether from making an analysis, than run the risk of working out erroneous conclusions by starting upon false premisses.

2. Moreover, it is very important that the physician should learn the amount of possible error attaching to the different methods which he makes use of, and always bear it in mind, when working out his conclusions.

I will point out these errors, as far as it is possible to do so, in each particular case; and will also make a few general preliminary remarks on the subject.

The amount of error attaching to any analytical method, that is to say, the difference between the result obtained and the absolute fact, depends upon two circumstances: 1. Upon the degree of correctness of the method itself; and 2. Upon the skill and care of the analyst, the goodness of his apparatus, the purity of his tests, &c. The degree of incorrectness of any method, though unavoidable, may be pretty accurately determined, and the value, indeed, of any method depends upon its degree of accuracy. The second fact is variable; when the analysis is badly performed the error is great, and *vice versâ* in a good analysis it is exceedingly small.

We cannot expect that every physician who performs a quantitative analysis should be an expert analyser; but it is quite necessary that he should know what degree of trust may be placed in his analysis. And this anyone may readily find out, by repeating several times the quantitative analysis of one particular constituent of the urine with the same materials, and using the same method. The greater or less concordance offered by the results of the different analyses at once enable us to judge both as to the correctness of the method and the skill of the analyst; we learn how far we may trust the figures obtained by him, and the value of the conclusions which are deduced from them. If in this way, and by repeated experiment, we have once determined the amount of error attaching to any analysis, we may, in cases in which great accuracy is not required, be contented with a single analysis. But in all quantitative analyses, where great accuracy is required, and where the materials suffice for a repetition of the analysis, a second analysis to control the first is always advisable, and if the results differ much, even a third; the mean sum of the three analyses being then taken as the result.

We frequently meet with cases where great accuracy is not required in the determination of the constituents of the urine: where, in fact, all we wish to know is, whether the urine contains more or less than a certain amount of one particular constituent. For example, a healthy man passes with his urine about 10 or 13 grammes of chloride of sodium in 24 hours; but in most acute diseases, when at their height, the amount of chloride of sodium thus discharged from the body is reduced to a minimum quantity. If, therefore, by an approximative method of analysis (which will be presently described) we find that less than one gramme of chloride of sodium is separated with the urine of a patient in 24 hours, we may safely conclude that a great diminution of the normal amount of the chloride of sodium in the urine has taken place. In most cases this information is sufficient for the purposes of the physician. He does not require to know the exact amount of chloride, whether it is 0·1, or 0·5, or 0·8 gramme.

Again, if we find, by a simple experiment, that a person passes more than 0·400 gramme of sulphuric acid with the urine in one hour, we have ascertained enough to satisfy us that the amount of sulphuric acid excreted is at least four times larger than natural.

Approximative calculations of this kind may be varied according to circumstances, and are of great service to the physician. They may be rapidly performed—in two or three minutes—whilst an exact estimation would require thirty or forty minutes for its completion. We must not, however, deduce from them any other conclusions than those which are warranted by the results obtained.

It appears from this that we may carry out the quantitative analysis of the urine in very different ways, according to the object which we have in view. A physician, who understands well what he is about, may, in certain cases, derive conclusions by means of an approximative quantitative analysis, rapidly performed in a couple of minutes, which are of more value to him than the results obtained through a careful analysis conducted by a highly skilled chemist.

The chemist may, in fact, have spent many days over the operation, and yet his labours be of no service to the physician, the particular point required by the latter having been overlooked by the chemist. This shows how important it is to keep clearly in view the object aimed at.

3. The indication afforded by the increase or diminution of any particular constituent of the urine must be considered separately under the head of each constituent; I may, however, premise a few general remarks, which refer equally to several of its constituents.

The constituents of the urine may be divided into two large classes, in accordance with their origin.

Those belonging to the first class are formed in the body, and are in fact products of the operations going on in the body. Urea and uric acid, compounds which are very rarely taken into the body as ingesta, are both of this class. A diminished quantity of these bodies in the urine shows, that they have either been produced in less quantity than normal, or that they have been retained and have accumulated in the body. Perhaps, in some rare instances, they may be evacuated in an abnormal way, or may undergo partial decomposition and conversion within the body. On the other hand, their increased secretion shows that they are either produced in abnormal quantities, or that they have been accumulated in the body, and then all at once evacuated with the urine.

Most of the constituents of the urine are comprised in the second class. They are either partially produced in the body or formed out of other compounds by chemical decomposition. Some of them merely pass through the body. The amount of them, which is separated with the urine, depends in part upon the activity of the metamorphoses going on in the body; in part, also, upon the quantity of them which is taken into the body as food, drink, medicine, &c. Thus, for example, the oxalic acid of the urine (as described in Section CI.) may be formed within the body, or it may have been taken into the body with different kinds of food containing oxalic acid. The sulphuric acid in the urine may result from oxidation of the sulphur contained in the proteine-compounds of the body; and it may also have been derived from the drinking of water containing sulphate of lime, &c. The quantity of chloride of sodium, again, contained in the urine may depend both upon an increased or diminished action of the kidneys; and also upon the amount of the salt which has been ingested with the food.

rtain circumstances, give rise to erroneous or inexact conclusions; nd these errors cannot be wholly avoided unless the original rocess be subjected to a long and troublesome modification. The rrors are as follow:—

1. The error connected with the presence of chloride of sodium in the urine. This has already been pointed out at p. 186, as well as the means of avoiding it. I have, therefore, only a few practical remarks to make on the point. In all cases in which we wish to obtain a very accurate estimation of the amount of urea in the urine, where, in fact, an error of from 1 to 2 per cent. is inadmissible, we must, first of all, precipitate the chlorine from the urine in the manner described at p. 186.

When great accuracy is not required, this tedious process may be omitted, and then we may follow two courses:

Either we may take no account whatever of the presence of the chloride of sodium. And then, in this case (excepting only when the urine contains no chloride of sodium, or only a trace of it), the urea will always stand at too high a figure. The error, indeed, may amount to 10 or even 20 per cent. It will, for instance, be great, if we compare the urine, usually rich in salt, of healthy persons, or of persons suffering from chronic diseases, with the urine of those who are suffering from acute febrile diseases, which generally contains very little chloride of sodium;

Or, we may make a correction for the amount of salt in the urine according to the quantity of the urea which has been obtained (see p. 186). This correction, however, is only approximative; and, spite of it, the error may still amount to as much as 5 per cent., and be either positive or negative.

2. A second source of error in Liebig's process results from the fact that other bodies may be precipitated with the urea. In such case the weight of the urea obtained will be too great. This is true of allantoine, a compound, however, which is rarely met with in the urine (see p. 189). It is true also of other nitrogenous compounds of the urine, which are more frequently present, and especially in the sick. Kletzinsky* found, in a number of carefully made experiements, that a nitrogenous compound is in most speci-

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* Kletzinsky, *Komparative Versuche über den Werth verschiedener Methoden der Harnstoffbestimmung.* Heller's *Archiv.* 1853. p. 252. (Comparative experiments relative to the value of the different methods of determining the urea in the urine.)

mens of urine precipitated by a solution of sugar of lead. This compound is not urea, but, in Liebig's method, it is precipitated with the urea, and is included in the calculation made of the urea. The quantity of this compound found by Kletzinsky amounted to 4, 3, 3, 2, and 2 per cent. in healthy urine. In the urine of disease it was much greater, amounting even to about 12 per cent. Hence the quantity of the urea, especially in the urine of the sick, may be set down at too high a figure; and in some cases the error may reach even to as much as 20 per cent. The error is often, to a certain degree, compensated for in this way: The urine in acute diseases contains very little chloride of sodium, so that the quantity of urea found in it, when compared with that in healthy urine, would be too small, unless correction were made for the chloride of sodium; such compensation, however, is only admissible in very superficial investigations, and must not be received where accuracy is required.

To avoid this source of error, it is necessary to add to the urine sugar of lead solution, rendered acid with a drop or two of acetic acid, until the whole of the matters capable of being thrown down are precipitated; any excess of lead remaining is then precipitated by sulphuretted hydrogen, and the urea determined by Liebig's method.

This source of error, which was first pointed out by Kletzinsky, may probably depend, in part at least, upon the fact, as late investigations indicate, that other bodies, some of which are constantly and some occasionally present in the urine, are, like urea, precipitated by nitrate of mercury. Thus, besides the compounds of ammonia and allantoine, which have been already described, we have creatinine, leucine, and tyrosine. The presence of these compounds interferes with the exact determination of the urea by Liebig's method. The quantity of them in the urine is, however, for the most part comparatively small, at least in healthy urine, seldom exceeding a few grammes in the 24 hours.

What indications are to be drawn from an increase or diminution of the quantity of urea in the urine?

The normal quantity of urea in the urine naturally forms the basis of our calculations on this subject. Numerous investigations, made by different observers, show, that a well-fed healthy adult man, passes on an average from 30 to 40 grammes of urea in the 24 hours, and from 1·25 to 1·66 gramme in one hour.

Thus, we find, calculating according to the weight of the body, that on the average in 24 hours from 0·37 to 0·60 gramme, and in one hour from 0·015 to 0·035 gramme of urea are passed for each kilogramme of the body's weight.

The absolute quantity of urea passed by women, and of course also by children, is somewhat less than by men. But, on the other hand, the relative quantity passed by children, in relation to the weight of the body, is greater than in adults. According to the researches of Uhle (Wiener, *Mediz. Wochenschr.* 1859, 7 to 9), children pass in the 24 hours for each kilogramme of their weight, as follows:—

Children	from	3 to 6	years of age,	about	1.0	gramme of urea.
,,	,,	8 ,, 11	,,	,,	0·8	,, ,,
,,	,,	13 ,, 16	,,	,,	0·4 to 0·6	,,

This quantity naturally varies somewhat in different persons, and in the same person at different times, according to the bodily constitution, nature of diet, and activity of the nutritive functions of the individual. Moreover, these numbers do not include the maximum and minimum quantities of urea which occur in certain cases in perfectly healthy persons.

The nature of the food has a very marked influence over the quantity of urea which is excreted. More urea is passed under a purely animal than under a mixed diet; and more under a mixed than a vegetable diet. Under abstinence from food, the smallest quantity is passed.

The observations of O. v. Franque (Treatise on the excretion of Urea in Man. Inaugural Dissertation. *Inaug. Abhdlg.* Würzburg, 1855) give us a very good idea of the degree of influence thus exercised over the excretion of urea. The quantity of urea passed by him in 24 hours,

Under a	purely animal diet,	was from	51 to 92	grammes
,,	mixed diet	,,	36 to 38	,,
,,	vegetable diet	,,	24 to 28	,,
,,	non-nitrogenous diet	,,	16	,,

The chief indications obtained from the quantitative determination of the urea in the urine, depends upon the fact: that the amount of urea is an approximative measure of the degree of metamorphoses of the proteine compounds going on in the body. Thereby we learn

The following examples are given as illustrations of the statements above given:—

A. In Health.

A large number of calculations made according to Liebig's method—no corrections being made for the chloride of sodium—gave the following as the quantity of urea found in the urine of strong healthy men on full diet:—

		grammes.
1 In H.	the mean quantity of urea passed per hour was	2·13
2 In M.	. . . .	1·47
3 In J. .	. . . . . . 1st series of experiments in the Summer of 1852	1·67
4 In the same person	2nd series of experiments in October, 1853 . .	1·86

The numbers given under 2, 3, and 4, are the mean of a large number, upwards of a hundred, of observations; consequently, they represent pretty accurately the mean production of urea in the individuals above referred to. They are, however, all of them somewhat too high, probably about 10 per cent., in consequence of the chloride of sodium not having been precipitated from the urine.

Most of the above observations also serve, singly, to indicate the amount of urea produced at different periods of the day. The hourly production of urea was as follows:

	Morning.	Afternoon.	Night.
In M. . . .	1·7	1·58	1·2
In J., 1852	1·68	1·71	1·61
In J., 1853	2·12	1·82	1·74.

From these figures it would appear, that the quantity of urea produced at different periods of the day does not vary much. During the night it was invariably less than during the day: observations also, made on the same individual at different periods of the year—as in J., in the Summer of 1852, and in October, 1853,—give nearly similar results.

To show the amount of variation in the quantity of urine passed in health from hour to hour, I will give the maximum and minimum of the hourly evacuation of urea in each of the above experiments:—

requires a diminished diet, the quantity of urea becomes less than normal.

During convalescence, the quantity of urea gradually again becomes normal.

This is the usual state of the urea as observed in these cases; but of course it may be variously modified by individual circumstances.

In intermittent fevers the excretion of urea is markedly increased during the accession of the fever. The increase occurs before the occurrence of the cold stage—an important fact in the history of fevers.

The quantity of urea is usually less than normal in most chronic diseases, which are accompanied with a diminution of the tissue-changes, or of the nutrition. During intercurrent exacerbations of fever, hectic fever, &c., it is increased.

The quantity is reduced to the lowest, when diminished nutrition is conjoined with diminished action of the kidneys; under such circumstances, and towards the fatal conclusion of many chronic diseases, the quantity is often very small, not more than from 5 to 6 grammes per day.

The quantity, again, is often much diminished in dropsical states of the body, a portion of the urea being dissolved in the dropsical fluid, and so retained in the body. When, however, in cases of this kind the secretion of the urine is much increased, either spontaneously or through the action of diuretics, the urea will for a time be separated in large quantities. The amount of the urea, under such circumstances, is much greater than the normal quantity which should be passed during that time; the excess of the excretion over the production of urea depending upon the amount of it, which has been retained in the body.

If, for a length of time together, much less urea is separated with the urine, than what may be considered the normal quantity, there is reason to fear that uræmia may result from the retention of urea and its decomposition within the body.

When urine contains a large amount of carbonate of ammonia, resulting from the decomposition of urea, there will naturally be comparatively less urea than normal in it; consequently, the quantity of urea found in urine which is very ammoniacal, is no true measure of the quantity actually produced. The proceeding, which must be followed, in such case, in order to determine the quantity of urea, is given at p. 188.

suggestion and with the assistance of my honoured friend. A c study of the relation of urea-secretion with particular diseases w lead us too far, and belongs indeed to special pathology. Those wish to pursue the subject further, will find it fully treated i following works:—Alfr. Vogel (Henle und Pfeufer's *Zeitschr.*, iv., 3) — S. Moos (Do. vii. 3) —W Brattler, *Ein Beitrag Urologie.* (A Treatise on Urology.) München, 1858. These works treat of secretion of urea in different diseases. W. Müller, *Harnstoffabsonderung, &c., nach operativen Eingriffen* (On the S tion of the Urea, &c.) *Wiss. Mittheil. d. Erlang. Phys. Soc.*, 1858, Heft 1.—R. Sander, *Harnstoffausscheidung bei pa Blödsinn.* (On the Secretion of Urea in Paralysis, &c.) Virc *Archiv.*, 1858, p. 160—F. S. Warneke *Harnstoffausscheidun Typhoidfieber* (The Secretion of Urea in Typhoid Fever, *Bibl Laeger*, xii. p. 330. The Secretion of Urea in Intermittent Fe Traube und Jochmann, *Deutsche Klinik*, 1855, No. 46—Si Ringer, *Med.-Chir. Trans.*, 1859, p. 360. The Secretion of in Cholera, Fr. Lehmann, *Inaug. Diss.* Zurich, 1857.

SECTION CXVII.

URIC ACID.

H. RANKE.—*Beob. und Versuche über die Ausscheidung der H säure beim Menschen*, &c. Munich, 1858. (Observations Researches concerning the Secretion of Uric Acid in Man, &c
B. J. STOKVIS.—*Bijdragen tot der physiolog. van het acid uri Ned. Tijdschr.*, 1859. Schmidt's *Jahrb.* Vol. 109, p. 3. (Tre on the Physiology of Uric Acid.)

The quantitative analysis of uric acid is to be conducted after method described in Section LXVIII. In all cases in which urine contains sediment of uric acid or of the urates—and it i these cases that the determination of the quantity of uric acid is r important—we must employ the whole of the 24 hours' urine the purpose; or, if the sediment should not be wholly dissolved i we must filter the urine, collect the deposit left on the filter, and it to the urates dissolved in the urine, and from both these toge calculate the quantity of uric acid. This proceeding is, however, tedious and troublesome, and will therefore be seldom resorted to by the physician, who is generally able to guess with sufficient accuracy the abnormal quantity of uric acid from the amount of sediment of uric acid, or of urates, which is present in the urine. It must, however, be remembered that we cannot in all cases conclude from the presence of uric acid sediment in the urine, that more uric acid than normal is passed with the urine in a given time (see Section xcviii.).

When we have determined the quantity of uric acid in the urine, we have next to learn whether the quantity obtained is normal, or is greater or less than normal. For this purpose, it is necessary to know, what is the mean quantity of uric acid passed daily or hourly by healthy persons. On this subject trustworthy data have been given us by Lehmann, Neubauer, and especially by Ranke.

According to these observers, the average quantity of uric acid passed in the 24 hours by adults (male as well as female) is from 0·3 to 0·8 gramme. This mean quantity, however, differs considerably in different persons. And even in the same persons at different times, greater or less, and sometimes very considerable, variations occur.

The nature of the food appears to exercise the chief influence over the excretion of uric acid. During fasting the quantity of uric acid is greatly diminished; it rapidly increases after eating, and indeed almost as much after taking non-nitrogenous, as after animal, food. (Ranke.—Dr. Roberts.)

In comparing the quantity of uric acid with the quantity of urea, we find considerable variations, from 1 to 28 up to from 1 to 80 gramme.

Lehmann passed on an average 1·18 gramme of uric acid in 24 hours; but he remarks that this is an abnormal quantity.

According to Becquerel the mean quantity is from about 0·49 to 0·56 gramme per day.

Neubauer, who made a great number of observations on two healthy persons, found in the one an average of 0·28 gramme, the maximum being 0·61, and the minimum 0·02 gramme; and in the other an average of 0·49, a maximum of 0·67, and a minimum of 0·33 for the 24 hours.

Ranke, who has made numerous investigations into this subject, and also many observations in his own person, finds that the average

quantity of uric acid passed by him in 24 hou
mean 0·648 ; the maximum 0·875 gramme ; tl
other persons, 0·225 — 0·654 — 0·556 —
In two women, the quantity was in one 0·41
0·429 ; and in the other 0·458 to 0·565.

Ranke found the excretion of uric acid incre
of intermittent fever. He also found that
patient suffering from leukæmia, that it was so
diabetes mellitus, and always markedly so in ch
out by Dr. Garrod and Neubauer). Accord
uric acid is in such case accumulated in the
found the excretion diminished by the ingest
sulphate of quinine.

The causes of, and the indications to be der
or diminution of the uric acid in the urine, ar
pothetical. Uric acid, like urea, is a product
fact, of the transformations of its nitrogenou
so far the increase or diminution of uric and
the same signification, viz., an increase or dim
morphotic processes of the nitrogenous elemen
acid, however, stands one step higher than
retrograde chemical metamorphoses ; for urea
uric acid by oxidation. Hence, indeed, uric a
as imperfectly oxidised urea ; and it has b
increase of the uric acid invariably takes plac
urea whenever, through imperfect supply of ox
nitrogenous elements of the body are not dul
quently in all diseases in which the respirator
This view, however, does not square with th
quantity of uric acid exists in the urine of the
Moreover, we find in those diseases in which a
acid is most constantly observed—in the a
diseases—that the urea is always increased as
We may, indeed, be sure that uric acid is
merely imperfectly formed urea ; but we must
vestigations to explain its actual mode of fo
signification.

We have already spoken of the indication a
tion of uric acid as sediment within the body (

SECTION CXVIII.

FREE ACIDS.

TH. EYLANDT.—*De Acidorum sumptor. vi in Urinæ acorem. Diss. Inaug.*, Dorpat, 1854.

J. CH. LEHMANN.—*Bibl. far Laeger*, vol. xiii. p. 18. *Schmidt's Jahr.* vol. 108, p. 148.

DR. WM. ROBERTS.—A Contribution to Urology, embracing Observations on the Diurnal Variations in the Acidity of Urine, chiefly in relation to Food. 1859.

The quantitative determination of the free acids in the urine is readily and quickly effected by the method given in Section LXIII. In such case, however, the analysis must be made as soon as possible after the evacuation of the urine; for the quantity of its acids is readily altered, under the influence of the acid or the alkaline fermentations.

Numerous observations, which have been made, partly by myself and partly under my superintendence, show that a man in health passes on an average between 2 and 4 grammes of acids in a day, and about 0·10 to 0·20 gramme per hour, calculated as oxalic acid. The hourly quantity varies much according to the period of the day. In a series of experiments made on four different persons, the quantity was found to be greatest during the night, least in the forenoon, and between these extremes in the afternoon.

The mean hourly quantity in an individual on whom the greatest number of observations were made, was in the night, 0·19; forenoon, 0·13; afternoon, 0·15 gramme.

The quantity of acids in the urine is undoubtedly diminished by the taking of caustic alkalies, carbonates, or of organic alkaline salts; in fact, the acids will entirely disappear if large quantities of these salts be taken, the urine becoming alkaline, just as it does in the formation of carbonate of ammonia by decomposition of urea.

On the other hand, the acidity of the urine is increased by taking mineral acids.

Example.—In a young man who had taken large quantities of sulphuric and hydrochloric acids for a long time on account of severe hæmoptysis, the average daily quantity of acid in the urine (as a mean of six days) was 4·4, and on one occasion reached to 7·5 grammes.

The numerous and careful observations made by Dr. W. Roberts confirm the statement of Dr. Bence Jones (see Sect. LXXXVII.), viz., that for a certain time—from one to three hours—after meals, the excretion of acids with the urine is diminished, both absolutely and also in relation to the solid constituents of the urine. Not unfrequently, indeed, the urine at this period becomes for a time even alkaline. In this respect animal and vegetable food has a similar action. Dr. Roberts ascribes the effect thus produced not so much to the secretion of the gastric acid juices (as Dr. B. Jones does) as to the passage of the alkaline salts of the food into the blood.

The amount of the acids in the urine, however, depends in all probability, not only on the quantity of acids taken, but also upon the tissue-metamorphoses going on in the body, as has been stated in Section LXXXVII.; but the mode of their formation has not yet been clearly shown.

Numerous calculations made concerning the quantity of acid in the urine of the sick show, that in most diseases, acute as well as chronic, the acid is diminished, and rarely ever increased, excepting in those cases in which large quantities of mineral acids have been taken. We find, however, that during the acute stages of febrile diseases, and particularly in pneumonia and acute rheumatism, &c., the percentage of acids in the urine is frequently increased, so that in fact the urine appears to be more acid than it is in health; but this manifestly depends upon the diminished quantity of the urine, and its consequent concentration. The diminution of the acids in the urine of the sick undoubtedly depends, for the most part, upon the diminished ingestion of food. No more special conclusions can be derived from observations hitherto made on this subject.

Examples.—In Men.

In a case of pneumonia, the quantity of acid gradually increased from 0· to 1·50. The mean of eight days was 0·5 gramme.

In another case of pneumonia, which ended fatally, the daily quantity varied from 0·9 to 3·0. The average of four days was 1·9 gramme.

In a case of gastric fever the quantity varied between 0·6 and 1·6. The mean of four days was 1·1 gramme.

In a case of acute rheumatism, the quantity during several days was 0·7 and 1 gramme.

In a case of chronic bronchial catarrh the quantity varied during eleven days between 0· and 0·8, the mean being 0·5 gramme.

In Women.

In a girl, who had scrophulous glandular swellings, the quantity was 1·6 to 2·4. The mean of four days 2·0 grammes.

In a woman, 30 years old, suffering from spinal irritation, 0· to 0·8. Mean of five days 0·4 gramme.

In a woman, 70 years old, suffering from ascites and liver disease, 0· to 3·1. Mean of eighteen days 1·41 gramme.

SECTION CXIX.

AMMONIA.

C. NEUBAUER.—*Journ. f. prakt. Chemie*, 44, p. 177 and 278.
W. HEINTZ u. H. BAMBERGER. *Würzburg. Medic. Wochenschrift*, vol. ii. parts 2 and 3.

The methods for determining the quantity of ammonia in the urine have been already described in Sections LXXII. and LXXIII.

It appears from the researches of Boussaingault, Heintz, and Neubauer that human urine always contains a small quantity of ammonia. From many experiments made by Neubauer on different individuals, the average quantity passed by healthy adult males in 24 hours was found to be about 0·7 gramme; the quantity may, however, be as small as 0·3, and as high as 1 gramme.

So few experiments have yet been made on this subject, and especially on the urine of the sick, that it is impossible for us to say with any certainty what indication the increase or diminution of ammonia in the urine offers to the physician. The following considerations, however, may serve as hints for assisting in the further investigation of the subject.

The ammonia found in the urine is evidently derived from two very different sources.

1. It is derived from the food and drink and from the air, which contains more or less of it. The quantity of ammonia, however, taken into the system in this way is generally small, and consequently the quantity excreted with the urine is, as a rule, insignificant, a little more than ½ gramme in 24 hours.

Under certain conditions, an abnormally large quantity of ammonia may be taken into the system by healthy persons, for example, when sitting in an atmosphere filled with tobacco-smoke, and by taking food which contains much ammonia, as horse-raddish, &c. In the sick, the ammonia may be introduced into the body as medicine in the form of carbonate and chloride of ammonium, &c. Neubauer has shown, that the greatest part of the sal-ammoniac which is thus taken into the body is evacuated with the urine. In all cases in which it is found that the daily amount of ammonia passed with the urine exceeds 1 gramme, the physician should ascertain on which of these causes the excess depends.

2. Ammonia may, undoubtedly, be also formed within the body, as the result of pathological changes. We know, that urea may be decomposed into carbonate of ammonia; and the idea at present held of the nature of uræmia is founded on this fact; the theory being, that the urea retained in the blood is converted within the body into carbonate of ammonia. All nitrogenous animal compounds, and particularly the blood and so-called extractive matters, readily give off ammonia out of the body, when only slightly decomposed; hence, we may conclude, that in pathological processes attended with the formation of putrid, septic, &c., matters, the development of ammonia has already taken place within the body. In such cases, the proof of an increased separation of ammonia from the body with the urine, is of much value in diagnosis. The ammonia, it is true, may be separated through the intestines and the lungs, as well as with the urine, but, with our present means of analysis, its quantitative determination is most readily and safely effected in the urine.

Great care, however, is required in these investigations, for under the conditions referred to, the urea in the urine readily passes into a state of decomposition (which, as Neubauer has shown, does not happen in normal urine). Consequently it becomes very difficult in such cases to determine how much of the ammonia found in the urine was originally present in it when secreted, and how much has been formed by subsequent decomposition, either within the bladder, or after the evacuation of the urine. In cases of this kind, to avoid the chance of error as far as possible, I would advise:

1. That the urine should be examined as soon as possible after its secretion from the kidneys; for which purpose the urine in the bladder should be drawn off with a catheter, and the catheter left in the bladder, and the urine then collected for investigation, as it drops from the catheter.

2. The urine thus collected should then be freed from its colouring- and extractive-matters, mucus, &c., by the addition of acetate and basic acetate of lead (after the manner described in Sect. LXXII.) in order to prevent any further decomposition of it.

SECTION CXX.

CHLORINE AND CHLORIDE OF SODIUM.

ALFR. HEGAR.—*Ueber die Ausscheidung der Chlorverbindungen durch den Harn. Giessen.*, 1852. (On the Excretion of Chlorine-compounds with the Urine).

F. HOWITZ.—*Hospitals Meddelelser; andere Roekke,* vol. i. p. 64, *Schmidt's Jahrb.*, vol. 95. p. 282.

E. PH. HINKELBEIN.—*Ueber den Uebergang des Chlornatriums in den Harn. Inaug. Diss. Marburg,* 1859. (On the Passage of Chloride of Sodium into the Urine).

The methods to be followed for the quantitative determination of the chlorine and chloride of sodium in the urine, will be found described in Section LVIII., and in the Analytical Examples, p. 268.

The method proposed by Liebig for the quantitative determination of the chloride of sodium, by means of nitrate of mercury (Sect. LVIII. I.) is very convenient, and may be performed in a few minutes. In cases, in which urine treated with baryta yields, after filtration, a perfectly clear fluid, very accurate results may be obtained. Not unfrequently, however, the moment, at which permanent clouding of the urine occurs on the addition of the mercury solution, cannot be exactly hit; and in cases of this kind, when the urine under investigation contains very little chloride of sodium, a considerable degree of error—as great as from 30 to 50 per cent—may attend the calculation. The physician, however, should always make use of Liebig's method, even in such cases, for the approximative calculation of the chloride of sodium in the urine usually adopted may yield errors equal to 100 per cent. The more complicated method of determining the quantity of chloride of sodium by means of a graduated solution of nitrate of silver (see Sect. LVIII. II.) need only be employed when very great accuracy is required.

The method of calculating the amount of chlorine in the ashes of the urine, gives very unsatisfactory results, for a considerable quantity of the chlorine is usually dissipated during the process of incineration. Consequently all the calculations formerly made by this process are untrustworthy and useless. It is quite immaterial, whether the result obtained is reckoned from the chlorine or from the chloride of sodium; although in many cases it is certain, that the whole of the chlorine contained in the urine is not combined with sodium. Care, however, should be taken not to compare tables of figures which indicate chlorine with those which indicate chloride of sodium; this has happened occasionally, and led to confusion; some writers giving their calculations in chlorine and others in chloride of sodium (Na Cl).

In order to judge whether there is any abnormal increase or diminution in the quantity of chlorine secreted with the urine, it is necessary that we should know what is the mean daily quantity of chlorine evacuated in health. Hegar has made a series of very careful observations on the daily and hourly secretion of chlorine with the urine in seven healthy young men. The average daily quantity of chlorine was different in each one, and varied between 7·4 and 13·9 grammes. The mean quantity of chlorine daily passed with the urine of a grown-up man, was about 10 grammes (= 16·5 grammes, Na Cl), and hourly about 0·44 gramme (= 0·73, Na Cl). These figures are probably somewhat too high, for the persons upon whom the experiments were made were most of them students, accustomed to a full diet and highly-salted food, and who drank freely. A somewhat lower figure would be more correct in the case of most healthy adults, about 6 to 8 grammes of chlorine (= 10 to 13 grammes, Na Cl) daily, and 0·25 to 0·33 gramme of chlorine (= 0·41 to 0·54 gramme, Na Cl) hourly. In the case of women and children the quantity of chlorine is still less.

Bischoff found the mean daily quantity of chlorine, secreted with the urine in a well-fed adult man, to be 8·7; in a woman, 43 years of age, 5·5; in a girl of 18, 4·5; in a boy of 16 years, 5·3; and in a boy of three years, 0·8 grammes. Becquerel found, in the ashes of a day's urine of a healthy person, only 0·66 gramme of chlorine, a result, like all results obtained by incineration, which is valueless.

Great variations in the daily and hourly quantity of chlorine thus separated from the body, occur not only in different individuals, but also in the same individual when in health. These variations follow a distinct law. In this country, the maximum quantity of chlorine is, in health, secreted during the afternoon, the minimum during the night.

Hegar found the mean quantity of chlorine secreted hourly in eight persons was: in the afternoon, 0·57; in the night, 0·28; and in the forenoon, 0·48 gramme. He also observed that variations from 0·20 to 1·32 gramme occurred in the quantity hourly secreted by the same persons, so that, in fact, the hourly maximum exceeded the minimum as much as even six times.

The following may be received as the correct answer to the question: What is the cause of the increase or diminution of the chlorine in persons in health?

1. The chief source of the chlorine in the urine is undoubtedly the salt which is taken with the food; consequently, the quantity met with in the urine is chiefly regulated by the quantity of salt thus ingested. Persons, who take large quantities of salt food, secrete a large average quantity of chlorine; and the temporary increased ingestion of chlorine-compounds is usually followed by an increased secretion of chlorine.

The greatest hourly average quantity of chlorine was passed by the individuals referred to in the above experiments during the afternoon and evening; and the reason of this is no doubt to be ascribed to the fact, that they took the largest quantity of salt with their chief meal at the middle of the day, a portion of the salt being separated from the body very soon after its entrance into the blood. Direct experiments also show, that the increased ingestion of chlorine increases the secretion of chlorine with the urine, and *vice versâ*.

Examples.—H. drank in the evening four glasses of water. The hourly average secretion of chlorine, which in him was only 0.13 during the night, rose in the first hours to 0·60, then fell to 0·12, and, later still, to 0·10 gramme;—in the morning it again rose to 0·51, without any food or drink having been taken, under the influence of increased nutritive changes caused by riding.

H. V. drank four glasses of water in the afternoon. The hourly average secretion of chlorine during the evening was 1·89, and amounted during the night to 0·57 (instead of 0·38 gramme). In the morning, two more glasses of water were taken; but the quantity of chlorine remained less than normal (0·42) during the whole day: during the night, indeed, it fell to 0·014;—in the morning it again rose somewhat (to 0·22), then fell again (to 0·18 gramme), notwithstanding that bread and butter had been taken with a considerable quantity of salt.

These facts show clearly that the amount of chlorine secreted does not depend solely upon the quantity of chlorine ingested, but that it is influenced by other causes, and especially by those which increase or diminish the action of the kidneys, and, consequently, the quantity of urine and the amount of urea. It is, however, very difficult to calculate accurately the amount of influence thus exercised over the secretion of the chlorine, and especially in any particular case. In attempting this, we must either supply the individual experimented on with food perfectly free from chlorine—whereby, indeed, it must be admitted that the correctness and utility of the results must be much disturbed; or the observer must take the trouble of accurately measuring the amount of chlorine contained in the food taken during the time of the experiment, as was done by Barral in some of his excellent observations.*

We will now consider the secretion of chlorine in disease. On this point I have myself made a considerable number of experiments, and have had experiments made by others. The results obtained are as follows:—

1. In all acute febrile diseases the secretion of chlorine with the urine rapidly diminishes, the quantity sinking to a minimum, so as sometimes to form scarcely one hundredth of its normal standard. The quantity increases as the disease passes away, and during convalescence is occasionally greater than normal. Its curve runs,

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* J. A. Barral. Statique chimique des animaux, appliquée specialment à la question du sel. Paris, 1850.

for the most part, parallel with that of the quantity of urine, usually in an inverse sense, like the curve of the specific gravity and colouring-matter of the urine, which is generally opposed to that of the urea at first, but frequently becomes parallel during convalescence.

Examples. The chlorine rapidly diminished in a man suffering from acute pleuro-pneumonia;—it amounted to 0·6 daily three days after the commencement of the attack; the next day to 0·3 gramme, and on the next almost reached 0;—from this point it continually increased; and, with tolerable regularity, as the disease passed away, and the appetite returned, until it reached the normal standard (0·4—1·8—2·6—5·5—9·0). At this point the curve became irregular, and occasionally exceeded the normal (10·7—13·5—9·7—11·9—15·9—10·8).

In a case of typhus the chlorine rapidly fell to a minimum, and remained several days at 0. It then gradually rose, as the disease passed away, but with variations, until it reached the normal standard.

In a woman suffering from acute rheumatism and pericarditis, the chlorine fell, during the height of the fever, to 1·0, and then gradually rose during convalescence, to 6·3 grammes.

In a young man suffering from severe febrile bronchial catarrh, it rapidly fell to 0·8, and then, within five days, rose to 10·6 grammes.

In an old man, also suffering from febrile bronchial catarrh, it fell to 1·1, and then, during convalescence, under the influence of good living, attained the enormous height of 20·5 grammes.

In a man attacked with exudative pleurisy, scarcely a trace of it was to be found in the urine: it then returned, and rose, with variations, without, however, reaching any high number (3·0—3·2—4·8—1·6—4·0—4·5—4·9—4·6).

The cause of this great diminution of the secretion of chlorine in all acute febrile diseases depends chiefly upon the loss of the appetite, and the saltless nature of the diet of the patients. In addition to this, there are also, occasionally, abstractions of chlorine from the blood, as in serous diarrhœa, exudations, &c. Under all these conditions, the chlorine of the blood is manifestly diminished; and, as we see happens in health, any excess of chlorine in the blood is separated by the kidneys, it becomes plain enough why the chlorine of the urine should be diminished. The excretion of chlorine is also, to a certain extent, dependent upon the quantity of urine; and as in all acute febrile diseases the quantity of the urine is considerably lessened, we must suppose that the diminished quantity of chlorine in such cases is in some way connected with the diminished quantity of urine.

Since the above conclusions, based on my own numerous observations respecting the secretion of chlorine with the urine in disease, have been published, many other memoirs have appeared on the subject: for example, those already referred to, by A. Vogel, Moos, and Brattler, on the subject of urea, which also speak of the excretion of chlorine. They confirm, in all main points, the conclusions above given; showing, in particular, that it is not in any particular disease, as in pneumonia for example, that the diminution of chlorine in the urine is observed, but in entire classes of diseases. They also show that the diminution or disappearance of chlorine-compounds in the urine cannot be employed for the purposes of differential diagnosis, as some would have it: as, for instance, in pneumonia. My observations have also been confirmed by those of Howitz, and F. Hoppe (*Deutsche Klinik*, 1858, No. 52) in reference to the fact that this diminution of the chlorine depends especially upon diminished ingestion of chlorine (the other above-mentioned causes being, of course, also taken into consideration).

An exception to the law, which holds good in all other acute diseases, occurs in the case of intermittent fevers. During the paroxysms of these fevers, and sometimes for a short time after them, but more rarely before their occurrence, the secretion of the chlorine is usually increased, and in some cases to a very great degree.

Examples.—W. K. was attacked with a tertian fever. A short time before the attack, the hourly quantity of chloride of sodium evacuated with the urine was 0·07; during the attack it rose to 0·62 gramme, then fell to 0·39, and, during the interval, to 0·17 gramme. During the subsequent attack, the quantity again rose to 0·93, and during the interval again fell to 0·04 gramme.

A. S. suffered from tertian fever. The hourly quantity of chloride of sodium, before the attack, was 0·05;—during the attack it was increased to 2·5 (!); afterwards fell to 0·12 gramme, and gradually rose to the normal standard, when the fever ceased.

A. C. had tertian fever. The hourly quantity of chloride of sodium secreted shortly before the attack was 0·42, during the attack it was 1·30, and then fell to 0·15 gramme. It again increased towards grammes, indidates diabetes insipidus, provided the quantity of chlorine ingested has not been especially increased by food or medicine. Its increase is a favourable sign only in cases of hydræmia and dropsy. By observation of the other constituents of the urine, we are often able to confirm or to modify the conclusions which have been arrived at by the observation of the quantity of chlorine.

SECTION CXXI.

SULPHURIC ACID.

G. GRUNER.—*Die Ausscheidung der Schwefelsäure durch den Harn.* Giessen, 1852. (The Excretion of Sulphuric Acid with the Urine.)

WALD. CLARE.—*Experimenta de excretione acidi Sulfurici per Urinam.* Dorpat, 1854. (Experiments concerning the Excretion of Sulphuric Acid with the Urine.)

P. SICK.—*Vers. über die Abhängigkeit des Schwefelsäuregehalts des Urines von der Schwefelsäurezufuhr.* Inaug. Abdhl. Tübingen, 1859. (Researches concerning the dependence of the Sulphuric Acid in the Urine upon the Sulphuric Acid ingested.)

The methods employed for the determination of sulphuric acid in urine have been described in Sect. LXIV. Both the methods, by weighing and by volumetrical analysis, when carefully conducted yield satisfactory results. The volumetrical process, without boiling, which is generally inconvenient to the physician, is the most rapidly performed; the result, however, is not very accurate, for error even to 10 per cent. may occur in its use. An approximative analysis may be more rapidly carried out, and although it is far from giving an accurate estimation of the quantity of sulphuric acid in the urine, generally suffices for the physician's purposes; it shows merely whether the sulphuric acid exceeds or is less than a certain quantity. An example will show the principle and the mode of carrying it into practice.

We will suppose, that the physician wishes to know whether the quantity of sulphuric acid separated with the urine of a sick person in 24 hours, without any addition whatever to the quantity of chlorine taken into the body. That which, in the first class of cases, in diabetes, tends to the injury of the body by the abstraction of its necessary constituents, acts in the last case, in dropsy, as a cure, by removing the superabundant matters. A certain quantity of chloride of sodium appears to be absolutely requisite for the production of many of the secretions, for the purposes of assimilation, the secretion of the gastric juice, of the bile, and for the formation of many of the tissues—especially of the cartilages?—and, on the other hand, an excess of chloride of sodium in the body may act hurtfully, and in particular, by interference with the blood-formation and destruction of the albumen.*

The quantitative analysis of the chlorine of the urine offers, in the present state of our knowledge, the following points for consideration:—

In all *acute diseases*, a constant diminution of the chlorine indicates an increment of the disease, and a gradual increase of the chlorine its decline. When the quantity of chlorine reaches a minimum figure—less than 0·5 gramme daily—we may conclude that the disease is intense, that there is an entire absence of appetite, and under certain circumstances that the patient has suffered from copious diarrhœa, or serous exudations. The reappearance of the chlorine in the urine enables us to form tolerably sure conclusions as to the state of the appetite and of the digestive powers of the patient. In cases of this kind an approximative calculation of the chlorine usually suffices; and an error of from 50 to 60 per cent. is not of much importance in those cases in which the secretion of chlorine is very small.

A knowledge of the quantity of chlorine in the urine in *chronic diseases* is of importance to the physician, because it affords him in most cases a tolerably sure measure of the digestive powers of the sick person. The presence of a large quantity of chlorine, 6 to 10 grammes daily, indicates good digestion; a small quantity, under 5 grammes, indicates weak digestion, provided that in such cases large quantities of chlorine are not separated from the body by any other means, by watery stools or exudations; and provided also that the diet of the patient is not such that only very little chlorine is ingested. A great increase in the secretion of chlorine, above 15 to 20 considerably increased by the ingestion of sulphate of soda; in experiment from 0·049 to 0·122 — 0·176 — 0·145 — 0·220; in another, from 0·041 to 0·138 — 0·122 — 0·164 gramme. increase of the acid was observed at longer or shorter intervals; other words, the sulphuric acid ingested was secreted from the in some instances more rapidly than in others. (Gruner.)

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* I have more fully explained this last fact in Virchow's *Handbuch der spec. Pathol. und Therap.* vol. i. p. 404.

According to Krause, the sulphuric acid is increased in the urine the internal use of sulphur; and so also, according to the experiments of Boecker and Clare, after the administration of large doses of sulphuret of antimony.

The researches of Sick show, that small doses of sulphate of soda, ten internally, are completely taken up, and afterwards evacuated th urine, but that when large doses are taken, a part only of the salt separated with the urine. This is what we should naturally expect on the purgative action of large doses of sulphate of soda.

2. The secretion of sulphuric acid is markedly increased by a full meat diet. This fact may be explained by the supposition, that the sulphur contained in the proteine compounds is separated during digestion, and by oxidation is gradually converted into sulphuric acid in the blood, and then secreted as such with the urine. This increase of the acid in the urine sometimes takes place in a few hours, after the ingestion of meat, and sometimes not until long after, 12 to 24 hours; the difference is probably to be ascribed to the digestion, whether it is slowly or quickly performed. The secretion of sulphuric acid is diminished by a vegetable diet.

Examples.—A person, who had taken in the evening a full dinner, consisting chiefly of meat, passed, between 12 o'clock at night and 9 in the morning, 0·50 of sulphuric acid per hour instead of 0·10; and during the following 24 hours the quantity greatly exceeded the normal, being 7·3 instead of 2·02 grammes.

Several persons whose excretions I examined, constantly passed more sulphuric acid after taking meat on the previous evening than when they had taken only bread and butter, rice broth, and so forth.

The experiments made by Clare upon himself are very instructive. During 3 days he took only animal food, and passed on the first day 2·094, on the second 5·130, and on the third 3·868 grammes of sulphuric acid. He then took ordinary food during 2 days, and passed the first day 3·592, and on the second 2·262 grammes of it. On the 3 following days, during which he lived upon vegetables, the acid amounted, on the first day, to 2·262, on the second, to 1·394, and on the third to 1·022; and on the 2 next days, on ordinary diet, to 1·979 and 2·859 grammes. From this it appears, that the increase of the sulphuric acid caused by animal food first appeared on the second day, but continued during the first day of the ordinary diet; and just in the same way that the diminution of the acid, produced by the vegetable diet, first showed itself on the second day, and also continued during the first day of the ordinary diet. Here, however, the phenomenon occurred later than in the cases observed by me, probably on account of some individual idiosyncrasy. A subsequent experiment made by Clare, viz. taking meat and vegetables on alternate days, was, however, without definite results.

3. Does the amount of sulphuric acid excreted with the urine invariably and solely depend upon the amount ingested, or (as has been already shown in the case of chloride of sodium), is its increase or diminution sometimes affected by other circumstances? Does the body, for instance, sometimes part with a portion of the sulphur or sulphuric acid, normally belonging to it, so as thereby to contain less than its normal amount of these constituents; or, on the other hand, is a portion of the sulphuric acid ingested retained in the body under certain circumstances, rendering the quantity abnormally large? These questions have not yet been satisfactorily answered. Gruner and Clare have endeavoured to ascertain, experimentally, whether rest or violent exercise influence the secretion of sulphuric acid; but their researches have not yielded any satisfactory results. Large draughts of water, which materially increase the secretion of urea and chloride of sodium, had no marked influence over the secretion of sulphuric acid. We are not, however, justified in concluding from these experiments, that the secretion of acid is not affected by such influences; for their power may be very slight, or, in the experiments referred to, may have been counteracted by opposing agencies. The fact above mentioned, viz., that sulphates and the sulphur contained in flesh, when ingested, are secreted more rapidly in some persons than they are in others, renders it exceedingly probable, that there are other conditions or forces inherent in the body itself, which regulate its secretion, and that these forces are different in different persons, and in the same person at different times.

Then, again, the well-known fact, that the sulphates taken for a long time in doses which are capable of being digested, have undoubtedly an enfeebling influence, is, in my opinion, a proof that under certain conditions, a larger quantity of them than normal may be retained in the body. To obtain a satisfactory answer to these questions, it is necessary either to determine accurately the amount of sulphur or sulphuric acid in the blood and the other parts of the body under different conditions, or to determine quantitatively the amount of sulphuric acid taken into the body as well as the quantity excreted. Both requirements are, however, so difficult of fulfilment, that it is probable the questions above proposed will remain long unsolved.

I have made several experiments concerning the excretion of sulphuric acid in the sick; but have not as yet obtained any particular results. I found that it was much diminished in most acute febrile diseases; the diminution no doubt depending upon the low diet and vegetable food of such patients.

Examples.—A man suffering from buccal diphtheritis, with much fever, secreted in 24 hours only 0·5 gramme of sulphuric acid. A patient with febrile catarrh, 0·29 and 0·38 gramme. A patient with pleurisy, 0·63 gramme. An exception was, however, observed in three cases of severe pneumonia; in these the acid was in part slightly diminished, and in part considerably increased. One of them, who had been treated with large doses of digitalis, passed 2·4, 3·1, 2·9, 5·7, 4·3, 1·8, 1·1, 1·6, and 2·7 grammes. The pneumonia was rapidly fatal in the other two cases; in the one, 2·9 and 1·4, and in the other 4·4 grammes were passed on the day the patient died.

A young girl with acute rheumatic fever secreted 0·8 gramme when the fever was at its height. One with erysipelas of the face, 0·48 gramme.

In chronic diseases the secretion of sulphuric acid was in many cases very small, in others somewhat larger, but generally much beneath the normal. It is generally less than normal in the dropsical, in whom, however, the excretion of chlorine is greatly increased during diuresis. In chronic diseases I found the acid increased only after the use of sulphuric acid or of sulphates, and in diabetic patients living on a rich animal diet.

Examples.—A patient, with icterus, passed 1·4; another, with rheumatism of the neck, 1·11; a patient with emphysema of the lungs, 1·2; another with amenorrhœa, 0·5; a girl with fluor albus, 0·7; a patient with habitual menorrhagia, 0·97 to 1·1 gramme of sulphuric acid. A dropsical patient, who, when diuresis had begun, passed with the urine 33 grammes of chlorine in 24 hours, secreted in the same time only 1·0 gramme of sulphuric acid, and on the following day (during which he passed 28 grammes of chlorine) only 0·5 gramme of the acid. A patient, who took sulphuric acid, secreted upwards of 3 grammes in 24 hours; and a patient suffering from diabetes insipidus as much as 5·2 grammes.

According to Dr. B. Jones, the sulphates are much increased in the urine in diseases in which the muscular system is much engaged; in chorea, for example; and so also in diseases of the brain, both functional and organic—in delirium and in inflammation. Heller asserts the same as regards inflammatory diseases; but he states that the sulphuric acid is diminished in chlorosis, neurosis, and in chronic diseases of the kidneys and the spinal marrow. The methods, however, followed by both these observers were not of a kind to settle this difficult question. Some observations made by Lehmann and Gruner are not favourable to their views. Observations made by myself in those diseases are not numerous enough to yield any definite result. The three cases of pneumonia, above mentioned, appear to show distinctly that the sulphuric acid is increased in many inflammatory diseases.

From the present state of our knowledge upon the subject of the increase or diminution of the sulphuric acid in the urine, the follow- conclusions may be drawn:—

1. A considerable diminution of the sulphuric acid indicates that the patient has taken very little food, or only vegetables without any meat.

2. An habitually large excretion of sulphuric acid, with an excess of urea, indicates a preponderance of animal food. A temporary increase indicates the ingestion either of sulphur or of sulphuric acid and its salts, or of large quantities of animal food.

3. We are not justified in considering that the increased secretion of sulphuric acid depends upon an abnormal decomposition of the sulphur-compounds of the body, except in acute febrile diseases, during which little or nothing has been taken in the way of food.

SECTION CXXII.

PHOSPHORIC ACID.

A. WINTER.—*Beiträge zur Kentniss der Urinabsonderung bei Gesunden.* Giessen, 1852. (Treatise on the Secretion of Urine in Health.)

F. MOSLER.—*Beiträge zur Kentniss der Urinabsonderung.* Giessen, 1853. (Treatise on the Secretion of Urine.)

W. BRATTLER.—*Ein Beitrag zur Urologie.* München, 1858. (A Treatise on Urology.)

H. KRABBE.—*Ueber die Menge der Phosphorsäure im Harn.*, &c. *Virchow's Archiv,* 1857, vol. xi. p. 478. (On the Quantity of Phosphoric Acid contained in the Urine.)

H. VON HAXTHAUSEN.—*Acidum Phosphoricum Urinæ et Excrementorum.* Diss. Inaug. Halle, 1860. (The Phosphoric Acid in the Urine and Fæces.)

The volumetrical method for determining quantitatively the phosphoric acid in the urine with per-chloride of iron has been already described in Sections LXI. and LXII. It unfortunately does not give satisfactory results. Notwithstanding the greatest care, an error to the extent of even 10 per cent. may occur, and especially so if the urine contains only a very small quantity of phosphoric acid. This has been pointed out in the Analytical Examples. But there are other sources of error to which the observer is liable, as for instance, that of taking a blue speck of different degrees of intensity as a sign of the saturation, or of allowing some time to elapse, after the addition of the per-chloride of iron solution, before proceeding to the test. These disturbing causes may render the error in the hands of an unskilful investigator as great as 20 or even 30 per cent. This method, therefore, is only of service for approximative calculations; and is not adapted for cases where accurate results are required. Conclusions derived from observations made according to it are only to be trusted when the differences obtained exceed 30 per cent. Differences between 15 and 30 per cent. are not worthy of consideration unless after a very large series of observations.

The new process with oxide of uranium (see Section LXI.) is decidedly preferable, and gives much more accurate results.

The observations given above, and those which follow, were most fasting; and that, on the other hand, it was nearly doubled under a rich nitrogenous diet.

Schmidt observed, that cats fed on ordinary food, for each kilogramme of weight passed 0·30 gramme of phosphoric acid in 24 hours; but that after a long fast they passed only 0·107 gramme of it.

3. It was distinctly proved in the case of chlorine, and was shown to be very probable in the case of sulphuric acid, that their excretion with the urine is influenced by different conditions of the system—by the nutritive changes, &c., as well as by the quantity of these bodies which have been ingested. Numerous experiments prove that the same is undoubtedly true of phosphoric acid. It has been already shown above, that phosphoric acid taken into the body with the food is excreted more or less rapidly in different individuals. It appears, from experiments made by myself, that a marked diminution of the phosphoric acid (0·085 gramme per hour) may follow a temporary increase of the excretion (0·216 gramme per hour). The secretion of phosphoric acid is usually increased by large draughts of water (together with the urea and chlorine), and in a greater proportion than the quantity contained in the phosphatic salts of the water. It is also increased by increased activity of the nutritive functions generally, or of the kidneys, or of both together.

From these facts it is evident, that the quantity of phosphoric acid in the body may, under certain conditions, be increased by retention of the phosphoric acid ingested, and diminished by increase of its secretion. Consequently, a knowledge of these conditions becomes of the highest importance both to the physiologist and the physician. Unfortunately, however, we know nothing certain concerning their nature, nothing in fact, except what is conjectural. And here, again, in our researches, we meet with the same difficulties as those which have been already mentioned, in reference to the determination of analogous conditions in the cases of chlorine and sulphuric acid. Besides this, it must be remembered, that the whole of the phosphatic salts are not secreted with the urine, a portion of them being, as a rule, passed with the fæces.*

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* V. Haxthausen has, at my request, made some observations on this point. He found, that the quantity of phosphoric acid evacuated with the fæces (as obtained from them without incineration, by extraction with dilute nitric acid) was as follows in the 24 hours:—Average (of seventeen observations) 0·666—Maximum, 1·080—Minimum, 0·270 gramme. From which it follows that four or five times more phosphoric acid is excreted with the urine than with the fæces.

Hence, it becomes necessary: either to determine quantitatively the amount of phosphatic salts in individual parts of the body, and under different conditions—which would require a vast number of experiments; or, to determine accurately both the quantity of phosphoric acid passed with the urine and the fæces, and the quantity of it ingested with the food. The difficulty of these processes, however, will prevent the attainment of the object desired; and we must therefore be contented, for the present, with conjectural views concerning the nature of the conditions which affect the increase or diminution of phosphoric acid in diseases.

The following are the facts which I have noted concerning the excretion of phosphoric acid in the sick; and on this point I have made upwards of one thousand observations.

In the first period of acute diseases, not of a severe nature, the excretion of phosphoric acid is frequently found to be less than usual, probably in consequence of the low diet taken; it then gradually increases in proportion with the quantity of food ingested by the patient. During convalescence, when an unusual amount of food is taken, the quantity of phosphoric acid is sometimes greater than normal.

In diseases of short duration, even although they are accompanied with much fever, the diminution of the phosphoric acid is at times scarcely perceptible.

Examples.—In a young man suffering from acute angina tonsillaris, the quantity of phosphoric acid excreted at the time of his admission into the hospital was 2·8 grammes.—Emetic; severe vomiting. Low diet. Next day the quantity of phosphoric acid was 1·7 gramme. The patient improved, quarter diet. On the third day, it was 2·6 grammes; on the next, 2·5. Half diet. On the following day the phosphoric acid was 3·2 grammes. Recovery.

Slight attack of pneumonia.—Recovery in eight days. The quantity of phosphoric was 2·4,—2·5—2·9—2·4—2·3 grammes.

In severe pneumonia, at the acute period of the inflammation: it was 1·7 — 0·8 — 2·1 — 1·2 — 0·9 — 2·1 — 1·9 — 1·1 grammes.

In severe pneumonia, it was 1·6—1·4—2·2—2·3—1·6 grammes.

In febrile bronchial catarrh: 1·4—1·5—1·7—1·5—2·8 grammes.

In convalescence after severe pneumonia: 3·8 — 2·7 — 3·2 — 3·5 — 3·9 — 1·8 — 2·5, &c., grammes.

In same: 1·9 — 5·6 — 2·8 — 1·5 — 3·2 — 2·8 grammes.

In convalescence after acute febrile bronchial catarrh: 4·8 grammes of phosphoric acid.

Eczematous catarrh of the digestive organs, with acute fever. Rapid course; the patient convalescent in eight days = 2·3 — 2·6 — 2·7 — 2·6 — 3·4 grammes.

The following cases occurred in females:—

Rheumatic fever: 2·1 — 2·3 — 2·2 grammes.
Catarrh of the stomach: 1·1 — 1·2 gramme.
Catarrhal fever, in the acute stage: 1·6 gramme.
Convalescence from typhus: 5·2 grammes.

In many cases of acute diseases, or after long abstinence from food, or towards the fatal termination of disease, the phosphoric acid excretion diminishes still more remarkably.

Examples.—In a girl, during the acute stage of pulmonary catarrh, the quantity of phosphoric acid was 0·7 — 0·5 —; and during convalescence 1·3 — 2·5 grammes.

In a case of pulmonary tuberculosis, on the days preceding the patient's death, it was 0·4 — 0·4 — 0·3 — 0·3 — 0·2 — 0·1 — 0·08 gramme (the day on which he died).

In fatal gangrene of the lungs, it was 3·0 — 2·5 — 2·20 — 0·7 grammes.

In some exceptional cases, however, the phosphoric acid may be greater than normal during the acme of acute diseases, as shown in the following example:—

In acute pneumonia in a middle-aged man, who was treated with large doses of digitalis, and recovered, it was 4·3 — 5·1 — 4·1 — 8·4 — 7·9 — 4·5 — 2·9 — 5·0 grammes.

In chronic diseases the secretion of phosphoric acid follows a very irregular course, the quantity being generally less than normal; sometimes, however, it is considerably greater. I have made numerous observations (30 to 40) on this point; but it would be tedious to mention them all here. I shall, therefore, give examples showing the mean, the maximum, and the minimum, quantity.

Examples in Men.—Emphysema of the lungs. The mean quantity of 8 days was 1·3; the maximum 2·3; the minimum 0·6 grammes.

Chronic broncorrhœa.—Mean of eight days 2·7; maximum 4·7; minimum 1·3 grammes.

Cancer of the liver.—Mean of eleven days 2·2; maximum 2·6; minimum 1·6 grammes.

Subacute articular rheumatism.—Mean of eighteen days 2·4; maximum 3·1; minimum 1·7 grammes.

Hemiplegia, after apoplexy.—Mean of thirty-five days 2·7; maximum 5·2; minimum 1·0 grammes.

Hydruria.—Mean of three days 5·0; maximum 5·8; minimum 4·4 grammes.

Dropsy.—Stage of diuresis, with great increase of chlorine-secretion. Mean of two days 1·8 gramme.

Examples in Women.—Diabetes insipidus. Mean of fourteen days 4·8; maximum 7·8; minimum 3·2 grammes.

Ascites.—Mean of fifteen days 3·0; maximum 4·7; minimum 1·7 grammes.

Chronic rheumatism.—Mean of seven days 3·3; maximum 4·2; minimum 2·7 grammes.

Spinal irritation, 2·1 — 2·8. Mean 2·4 grammes.

Amenorrhœa, 2·1 — 2·3. Mean 2·2 grammes.

Scrophula, 2·6 — 5·2. Mean 3·5 grammes.

Pulmonary tuberculosis, 1·5 — 3·9 (10 days) grammes.

Chronic erysipelas of the face, 1·5— 3·6 (11 days) grammes.

Brattler gives the following résumé of his observations on the sick:—The excretion of phosphoric acid is *diminished,* in diseases and functional disorders of the kidneys, associated with diminished urinary secretion (Bright's disease, diseases of the heart), and in diseases of the digestive organs, which interfere with the absorption of the food. It is *increased* in acute febrile diseases, through the increased metamorphoses of the phosphorus-containing tissues (the increase of the phosphoric acid, however, is not so constant as is that of the urea); it is also increased in diseases where, through functional disorders of the kidneys, the phosphoric acid has been retained and accumulated in the blood, after the cause of the retention has been removed. (Bright's disease, cholera.)

Haxthausen observed a diminution of the secretion of phosphoric acid during the access of intermittent fever.

SECTION CXXIII.

EARTHY PHOSPHATES.—LIME.—MAGNESIA.

BENEKE.—*Der Phosphorsäure Kalk.,* &c. Göttingen, 1850. (Phosphate of Lime, &c.)

Beneke.—*Zur Physiolog. u. Patholog. des Phosphors. u. oxals. Kalkes. 2 Beitrag.* Göttingen, 1850. (On the Physiology and Pathology of Phosphate and Oxalate of Lime.)

Kletzinsky.—*Heller's Archiv*, 1852, p. 270.

C. Neubauer.—*Ueber die Erdphosphate des Harns. Journl. für pract. Chemie*, vol. lxvii. p. 65. (On the Phosphatic Earths in the Urine).

F. Huenke.—*De Phosphatum terrarum in urinâ quantitate.* Diss. Inaug. Berlin, 1859. (On the Quantity of Earthy Phosphates in the Urine.)

Different methods are employed for determining the quantity of earthy phosphates in the urine, according to the particular object which the operator has in view.

1. The quantity may be estimated by Beneke's method (Sect. lxxxiii. 1.). This method is quickly performed, but it yields only approximative results.

2. Again, the quantity may be obtained by the method described at p. 193. The earthy phosphates are precipitated with ammonia, the precipitate washed, dissolved in hydrochloric acid, and the quantity of phosphoric acid in the solution determined by the volumetrical process. This method, however, is liable to the errors, mentioned under the head of phosphoric acid, and does not yield accurate results. Moreover, it does not give the weight of the earthy phosphates themselves, but only the quantity of phosphoric acid.

(3). Again, the quantity of lime and of magnesia is determined separately, either,

3. According to the method given in Section lxxi. III.; or,

4. According to Section lxxi. I. and II.

The last-mentioned method (4) is preferable to every other when great accuracy is required.

The following data will assist the inquirer in determining the value which may be attached to quantities obtained by these different methods:—

Beneke considered that the quantity of earthy phosphates passed with the urine by an active healthy man in 24 hours, equalled 1·2 gramme.

Lehmann passed in 24 hours 1·09 gramme of phosphates under ordinary diet; and 3·56 grammes under a purely animal diet.

Böcker passed an average daily quantity of 1·48 gramme.

Mosler found the quantity of phosphoric acid united with the earths (consequently not the quantity of the phosphatic earths themselves) which was passed by himself, first, during six days' observation in the month of April, and secondly, during four days in October, as follows:—

	I.		II.	
	Per Day.	Per Hour.	Per Day.	Per Hour.
Mean . .	1·152	0·048	0·390	0·015 gramme.
Maximum	1·800	0·075	0·660	0·027 „
Minimum	0·370	0·015	0·170	0·007 „

In other healthy persons the hourly average was from 0·015 to 0·019 gramme.

Hegar found the quantity of phosphoric acid combined with the earths, to be, in himself, as the mean of eight days' observations, 1·31 gramme. Half-a-year later, the mean of four days' observations was 0·902 gramme.

Neubauer gives the following as the results of the numerous observations which he has made. They may be received as very trustworthy, both from the accuracy with which the observations were made, as well as from the number of them, 52.

The average quantity of earthy phosphates passed with the urine by a healthy man in 24 hours range between 0·941 and 1·012 grammes. The mean maximum was 1·138 to 1·263 (the greatest quantity being 1·554). The mean minimum 0·8 (the smallest quantity 0·328) gramme.

The average daily quantity of phosphate of lime was 0·31 to 0·37 gramme. The mean maximum 0·39 to 0·52 (the largest quantity 0·616). The mean minimum 0·25 (the smallest quantity 0·15) gramme.

The mean quantity of phosphate of magnesia was 0·64. The average maximum 0·77 (the largest quantity 0·938). The average minimum 0·5 (the smallest quantity 0·178) gramme.

On an average there was excreted 1 equiv. of phosphate of lime to 3 equivs. of phosphate of magnesia, or 33 parts of phosphate of lime to 67 parts of phosphate of magnesia.

These data are strikingly opposed to those of Kletzinsky, who found the relative quantity of the phosphate of lime and phosphate of magnesia exactly the reverse. According to him, 100 parts of the earthy phosphates consist of 67·3 phosphate of lime, and 32·7 phosphate of magnesia.*

It appears, from the investigations of Neubauer, that salts of lime, when taken into the body, do not pass into the urine, or at all events only in very minute quantities. On the other hand, Dr. W. Roberts found the earthy phosphates increased to almost double the ordinary quantity after eating.

The absolute quantity of earthy phosphates in the urine, as well as the relative amount of the phosphates of lime and of magnesia, vary much in disease from the normal standard above given. Thus, it is generally admitted, that the excretion of phosphatic earths, and especially of phosphate of lime, is increased in certain diseases of the bones (osteomalachia, rickets, &c.). Further careful investigations are much to be desired for the more perfect illustration of this subject, which is of great importance in pathology as well as in physiology. In conducting such investigations, we must remember, that if conclusions are drawn from them respecting the metamorphosis of the whole of the phosphatic earths in the body, the phosphates contained in the fæces must be calculated as well as those in the urine.

SECTION CXXIV.

Creatinine—Allantoine—Leucine—Tyrosine.

Creatinine is constantly present in the urine. The quantity of it was once regarded as very small; but later investigations show that such is not the case, and that it is of importance that we should be able to determine its quantity. For this purpose, methods for its quantitative determination in the urine have been given (see Section LXIX.).

Schottin (*Archiv. d. Heilkd. v. Wagner.* 1860. vol. i., p. 417) found only traces of creatinine in the urine. Neubauer, however, showed by a series of careful investigations (*Annal. d. Chem. u. Pharm.*, vol. cxix., p. 27), that the quantity is much greater than

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* The process employed by Kletzinsky was found, on trial, to give inaccurate results. His conclusions, therefore, on this head cannot be accepted.

Schottin supposed. He found in his own urine 1 gramme in 24 hours; the maximum being 1·35, and the minimum 0·76 gramme. He obtained similar results in other adult persons, 0·8 to 0·9 gramme per day. In a boy he found 0·4 gramme.

Creatinine appears to be essentially a product of the metamorphoses of muscular tissue, and its increase to play an important part in many diseases. Thus in uræmic diseases it appears to be increased in the blood; and is perhaps also increased in the urine. It is to be hoped that further investigations will be made in this field, which promises rich rewards.

The determination of the presence and of the quantity of allantoine, leucine, and tyrosine in the urine also promises to add to our pathological knowledge. Our information in this direction is as yet but fragmentary and of little service to the physician. I add the following literary notices on the subject for the benefit of those who may be inclined to study the subject further.

Frerichs and Städeler (*Müller, Archiv f. Anat. & Phys.*, 1854, p. 393) found allantoine in the urine of dogs, whose respiration was impeded; so also did Köhler (*de allantoini in urinâ impeditâ respiratione præsentia*), Diss. Görlitz, 1857. Schottin also found it in man after the ingestion of large quantities of gallic acid (Lehmann's *Handbuch der Physiol. Chemie*, 1859, p. 93).

Schottin (*Archiv f. Physiol. Heilkde.*, 11. N. f., p. 353) found leucine in a specimen of albuminous urine; Frerichs and Städeler found leucine and tyrosine in the urine of patients suffering from typhus and small-pox, as well as in acute atrophy of the liver. Schmeisser also found tyrosine in the urine of a patient suffering from the last-mentioned disease (*Archiv d. Pharm.*, Oct. 1849, vol. 150. p. 11).

SECTION CXXV.

CONCLUDING OBSERVATIONS.

I have endeavoured in the preceding pages to point out, for the purposes of the physician, the signification of the different changes (qualitative and quantitative) to which the urine is liable, in the same way as medical semiology points out and determines the value of the

9; chlorine—20 to 30; phosphoric acid—5 to 9; sulphuric acid—to 5 grammes. Not a trace of sugar was found in it. Diagnosis: diabetes insipidus.* The patient was manifestly suffering from abnormal increase of the metamorphic processes. The waste of the body was unnaturally great; and as the patient was in poor circumstances, this increased loss was not replaced by a richer diet. In two days the weight of the body was diminished three pounds. The calorification of the body was, however, less than normal, and the formation of blood-corpuscles defective. Under an abundant and rich diet, together with the use of tonics (quinine and iron) and opium, the urinary secretion was gradually brought to its normal state; the patient's aspect improved, the nervous symptoms disappeared, and her strength returned. Whenever, however, the patient returned to her previous mode of living, she had repeated relapses of the disease—intermitting diabetes insipidus.

I have often observed analogous cases as the consequence of immoderate water-drinking, of hydropathy carelessly or improperly employed, or too long continued.

3. A strong man, after a chill, complained of severe rending pains in the neck and shoulders. The skin was cool and shrivelled, the perspiration diminished. His urine was increased—3000 to 3300 C. C. The quantity of colouring-matter was about normal—4 to 5; and so also that of the free acids—1·8 to 2·3. The specific gravity low, 1·006 to 1.008; and the amount of solid constituents somewhat diminished—36 to 40 grammes; the urea, phosphoric acid, sulphuric acid, and chlorine being rather less than the normal sum. Diagnosis: hydruria. The increase of the urine evidently depended upon an increased secretion of water by the kidneys, which occurred vicariously with a diminished secretion of the skin and the lungs. Although the hydruria continued several days, the strength and the weight of the patient did not diminish. Under a diaphoretic treatment, whereby the secretion of the skin was increased, the hydruria gradually disappeared; and so also did the rheumatism of the neck after cupping.

4. In a young man suffering from disease of the heart—insufficiency of the bicuspid valves with consecutive dilatation and hypertrophy of the right ventricle—the urine gradually diminished in quantity, from 1600 to 1200, 800, and 600 C. C.; the secretion of urea was also diminished to 26, 20, and 18; and so also the secretion of chlorine to 8, 5, and 3; the phosphoric acid to 2 and 1·5;

and the sulphuric acid to 1·5 and 1 grammes. Then foll dropsical effusion into the abdomen, and oedema of the ext ties. Under the use of large doses of digitalis—infusion of talis with acetate of potass—the urine was considerably incr to 3000, 4000, and 4500 C.C.; and with the urine a conside quantity of urea, 50, 55, and 60; and of chlorine 25, 30, a grammes were evacuated; the sulphuric acid and phosphori secreted were, however, scarcely more than usual. In this large quantity of water, urea, and chlorine, instead of being eva with the urine, had been poured out and collected as dropsica sions, which were gradually removed by the abundant diuresis cially produced. The same thing occurred several times i patient; gradual diminution of the urine, dropsical effusion then, after the use of diuretics, increased secretion of water, and chlorine with the urine.

5. An elderly man, whose arteries were remarkably rigid, w tacked by a somewhat acute bronchorrhoea, the disease extendin both lungs. The condition of the patient varied remarkably. attacks of dyspnoea, with small and rapid pulse of 100 to 126 which sometimes rendered him senseless, alternated with int of ease. Examination of the urine showed that corresponding tions occurred in the nutritive functions of the body. During days not more than from 300 to 400; whilst on other days from to 1500 C.C. of urine were evacuated. Its colour changed from yellow to red; the colouring-matter—from 2 to 18—was u increased (access of fever); the specific gravity was of an a number—1·012 to 1·023; the average amount of solid consti considerably less than normal—18 to 30 grammes. The ure varied much, but, despite the fever, was on an average much than normal—12 to 25 grammes; the urine also frequently tained a sediment of urates. The chlorine showed the gr variations; it was invariably diminished, sometimes only a tra it being found in the urine—0·1 to 5. The phosphoric aci sulphuric acid were also diminished. These great variations i metamorphic processes of the patient, indicating a profound turbance of the constitution, together with the lung-affection, l to fear a speedy collapse; which, indeed, occurred very sud In the evening the patient had expressed himself as feeling than usual; but during the night he complained all at once of weakness and faintness, and died in the course of a few hours,

of all the stimulants administered. Death was caused by the rapid progress of the pulmonary œdema.

6. A man, 57 years old, was attacked with pneumonia on the left side, the consequence of exposure to severe cold on a journey. He was first treated with cupping and large doses of digitalis. The fever was very acute; the urine less scanty, than in other like cases, 900, 1000, 1950, 1500, 1350, 1200 C.C., and of high colour; the pigment-matter considerably increased—28 to 32; the specific gravity somewhat higher than normal—1·018 to 1·024; the solid constituents for the most part above, but occasionally less, than normal. The urea increased—40 to 60; the sulphuric acid was increased, in the first instance—3·5 to 4 grammes, but afterwards was less than normal—1·8, 1·1 and 1·6; the phosphoric acid nearly constantly increased—4, 5, 7, 8 grammes. Of chlorine only a trace could be found during the first two days; but it gradually increased —3, 4, 7 grammes, and on the eighth day was normal. The patient rapidly recovered, despite his advanced age, and of his having previously suffered from an attack of pneumonia, which had probably injured his lung; and he left the hospital cured in ten days. The case is particularly interesting as showing the favourable effects of digitalis on the nutrition. Here, as in all cases of acute fever, there was an increase of the wear and tear of the constituents of the body, an unusually large amount of urea and colouring-matter was formed, and an increased quantity of phosphoric and sulphuric acids were separated from their organic compounds. The urine, however, was in this case, and doubtless through the influence of the digitalis, much more abundant than it usually is in such cases; and in consequence the products of the decomposition of the tissues, &c., were rapidly removed from the body, and convalescence hastened. I do not mean to say that this is the only action of digitalis in such cases; but I refer to this peculiar action of the medicine on account of its being so clearly manifested in this case.

7. A man suffered from chronic affection of the liver and the stomach, with organic change of structure, of a nature not easily diagnosed, associated with long-continued disturbance of the digestion, as well as severe pain. His strength was much exhausted. Here the indication was, in the first place, to provide for the immediate treatment, and then, for the sake of prognosis, to investigate more closely the metamorphic changes going on in the patient. For this purpose the urine was examined on several days; and the following were found

to be the average proportion of its constituents:—the quantity was about normal—1·500 C. C.; the colour clear yellow, the colouring-matter less than normal—3; its reaction slightly acid, its free acid being much diminished—0·4. The specific gravity was less than normal—1·014; and so also the solid constituents—42 grammes. The urea was somewhat diminished—29; and so also the sulphuric acid—1·4; the phosphoric acid was about normal—3·3; and the chlorine—10 grammes, rather above the normal. From this it followed, that for a time digestion was favourable, the chlorine and phosphoric acid being sufficient; but that, on the other hand, the metamorphosis of the proteine-tissues was diminished, the urea and sulphuric acid being deficient. The small amount of colouring-matter, and the marked diminution of the free acids indicated also a defective metamorphosis of the blood-corpuscles—a fact which was also indicated by the pale anæmic appearance of the patient. Under the influence of an abundant animal diet and tonics, the patient gained strength and spirits at least for a time; but, from the nature of the organic disease, no permanent cure could be expected.

8. Cases occur, in which a febrile increase of the metamorphic processes can scarcely be discovered, except from the condition of the urine. The pulse is perfectly quiet, the temperature of the surface of the body about natural, the appetite little affected; and yet there is an increase in the waste of the constituents of the body, and diminished activity of the kidneys—a condition always dangerous, as a cause of congestion in cases of chronic disease of the lungs, liver, &c. Congestion, under such circumstances, readily occasions material changes in the structure of parts. The following case comes under this head:

A very powerful man, 48 years old, with a broad and well-arched thorax, presented symptoms, which led to the suspicion of the existence of commencing tuberculosis. For a long time he had suffered from cough and expectoration; slight dulness of percussion at the apex of the right lung, with indistinct and somewhat bronchial respiration, and râles at this point. His inspiratory capacity was less than his bodily size would indicate. During the last few months he had wasted somewhat and lost strength. His pulse, however, was perfectly quiet, 60 to 63; his appetite tolerably good; ¼-diet, with different extras; the temperature of his extremities not increased. During the night he occasionally had severe sweating. The urine, on the other hand, was very abnormal. It was much diminished in quantity — 400 to 600 C. C.; almost always clouded with an uric acid sediment; very high-coloured, the pigment-matter being increased — 16 to 24; of very high sp. gr.—1·022 to 1·028; the urea rather above the average—28 to 35; the chlorine much diminished—3 to 5; the phosphoric acid—2·5; and sulphuric acid somewhat less than normal—1·5 grammes. Hence, the excretory action of the kidneys was much diminished; the wear and tear of the tissues much greater than natural, and the blood, in consequence, overcharged with deleterious constituents. It appeared, moreover, that the patient had long suffered from some chronic disease of the skin (probably psoriasis), and that this disease had disappeared about six months ago. Many circumstances therefore combined together in causing an inordinate action of the lungs, and must have aided in promoting the disorganisation of their structure, which was suspected to be going on. On careful investigation, it was found that, despite of the slow and tranquil pulse, there was increased action of the right ventricle; and a congested state of the lungs was indicated by a distinct increase of the second sound of the pulmonary artery. The patient, besides, complained of dyspnœa and tightness at the chest. The main indication was, by increasing the urinary secretion to free the lungs from the irritation excited in them by the excess of excretory matters which were retained in the blood. Gentle diuretics were administered—infusion of digitalis with acetate of potash; and infusion of herba Jaceæ. With increase of the quantity of urine, the patient's chest became more free, and his general condition improved; so that after a time he was able to leave the hospital materially improved in health. Out of the hospital, however, he could not obtain suitable nourishment, and indulged deeply in spirits; his disease in consequence advanced, and in about six months time he returned to the hospital with well-marked tuberculosis of the lungs, and died in the course of a few days.

9. A man, 45 years old, was suddenly seized with acute febrile symptoms, shiverings, and heat, loss of appetite, and bloody urine. In the course of 36 hours the whole of his body, with the exception of his face, became œdematous. A few days later the patient was brought into the hospital, presenting the symptoms above described, with the addition of constant vomiting. During the first three days of his residence there, the condition of the urine was as follows:—Its quantity less than normal — 900 to 1500 C.C.; its colour a deep blood-red. Under the microscope, a largish quantity of un-

changed blood-corpuscles was found in it, as well as numerous pus-corpuscles, and a few granular urinary casts. It was highly albuminous. Its reaction alkaline; sp. gr. low—1·010 to 1·012; its urea much less than normal—8 to 20; chlorine diminished—1 to 3; and so also its phosphorus—1·3 to 2·8; sulphuric acid much diminished—0·5 to 1·6 grammes. After standing for some time it deposited a mucous sediment, resulting from the action of the ammonia on the pus-corpuscles suspended in it. The perspiration—cutaneous and pulmonary exhalation—was much less than normal, 460 to 780 grammes in the 24 hours. The ingesta exceeded the egesta considerably, so that the patient increased ten pounds in weight in the course of three days, in consequence of the increase of the dropsical swelling. Diagnosis: Morbus Brightii acutus. The most powerful remedies were used to increase the urinary and intestinal secretions, in order to ward off the consequences of the uræmic condition of the patient; but without effect. All internal remedies—sulphate of soda with acetate of potash, gamboge, with carbonate of soda, croton oil—were rejected by vomiting; external applications of decoction of digitalis over the whole surface of the body were without any effect. Clysters of croton oil in linseed oil irritated the rectum so much, that they could not be repeated. The excretory action of the kidneys daily diminished; the quantity of urine fell from 800 to 700, 500, and 450 C.C. per day; its sp. gr. from 1·015 to 1·010. The quantity of urea still further diminished—6 to 8 grammes daily; and in like manner the chlorine—0·8 to 1; the sulphuric acid—0·4 to 0·6; and the phosphoric acid—1·3 to 1·7 gramme. Symptoms of uræmia, giddiness and delirium, appeared, and gradually increased into coma and sopor, destroying the patient in a little less than three weeks from the commencement of his illness. The autopsy showed the existence of Bright's disease in the second stage.

10. A man, 52 years old, of strong bodily constitution, was, like the last patient, attacked with acute disease of the kidneys. Considerable œdema of the whole body quickly followed upon the febrile symptoms; the blood-red urine contained a large quantity of albumen, and presented under the microscope, traces of urinary casts, together with numerous blood-, and pus-corpuscles. In this case strong diuretics—pills of gamboge and carbonate of soda produced an abundant urinary secretion, and especially after decoctions of digitalis had been extensively applied over the whole of the lower half

of the body. The urine from the 25th of October to November 1st presented the following characters: quantity much increased, from 4800 to 6800 C. C.: colour red (bloody); reaction neutral or alkaline; specific gravity low—1·003 to 1·005; urea much increased, from 45 to 97 grammes daily; and so also the chlorine—20 to 30; the sulphuric acid—4·1 to 4·7; and especially the phosphoric acid—11 to 18 grammes. The dropsical swelling entirely disappeared with the increase of the urinary secretion; and so likewise did the threatening symptoms of uræmia (somnolence and wanderings), leaving the patient to all appearance quite well. After a time, however, he had another attack; violent fever with swelling of the lips and phlyctenous eruption around the mouth, with scanty and very bloody urine. As the latter symptom indicated acute irritation of the kidneys, and as there was a complete absence of dropsical symptoms, diuretics were not administered; and I considered it of importance to lessen the irritation of the kidneys. Linseed-tea with bitter almond-water was given; and in the course of two days the former deep bloody-looking urine became almost colourless.

11. Hæmaturia, resulting from solution of the hæmato-globuline (see Section XCI.). A young man, 20 years old, who had always previously enjoyed good health, complained that for the last 8 days he had felt unwell. His face was remarkably pale, and in some parts livid; reddish-blue rings were broadly marked under the eyes. The temperature of skin natural; pulse quick—90 to 100, small and weak. Together with a feeling of great weariness and depression, he experienced pain of a slightly tearing, and dragging nature over the greater part of the body, and particularly in the extremities. There was slight catarrh of the respiratory and digestive organs, want of appetite, a somewhat coated tongue, diarrhœa, and distinct enlargement of the spleen. He was taken into the hospital; and supposed, though erroneously, to be labouring under typhus. The febrile symptoms diminished instead of increasing; the weak, and often double-beating pulse became slower and fuller: the heat of the body remained natural, being generally under 37° C. (99° Fahr.), and the intelligence unaffected. The patient, however, became gradually weaker, so that he could scarcely raise himself up: and the anæmic appearance so marked as to give him the appearance of a patient in an advanced stage of cholera. The urine, natural in quantity, was of a dark brownish-red colour, between 7 and 8 of the colour-table—similar, although not quite as dark as that which I had observed after

the inhalation of arseniuretted hydrogen (see p. 310). It contained at least 300 parts of colouring-matter. No blood-corpuscles could be found in it under the microscope, in fact, no kind of solid matters. On boiling it yielded a very abundant reddish-brown coagulum of hæmato-globuline, which when separated by filtration was of a slight yellowish-colour. Its other constituents were normal in quantity, with the exception of the chloride of sodium, which was somewhat diminished in consequence of his scanty diet. This state of the urine, which had undoubtedly existed from the beginning of the complaint (of which he could give no account), lasted for about 8 days, and then gradually disappeared. It indicated, that the disease consisted essentially in a continued partial decomposition of the blood-corpuscles within the vessels—the product thereof being separated with the urine (and perhaps also with the bile)—causing, by the intensity and duration of the complaint, an advanced condition of oligocythæmia. The state of the urine, combined with the great depression, and the pains in the extremities, also indicated scurvy; but here there was no characteristic change of the gums, nor ecchymoses, &c., nor any etiological cause to account for the production of scurvy.

Mineral acids were given to the patient, first of all alone, and then in combination with quinine; and during convalescence preparations of iron. He recovered slowly, but completely. No effective cause of the complaint was discovered.

Some months later, and without any appreciable cause, another attack of hæmaturia occurred, but of shorter duration and less intense than the former. During this attack, as during the former, the patient did not suffer the slightest pain in any part of the urinary system ; nor could any satisfactory cause of the affection be discovered.

12. The following case, essentially different from the former, but arising without appreciable cause, presents an example of hæmaturia vesicalis. Friedrich P., butcher, æt. 22, who had never before been ill, and whose parents were healthy (his father suffering merely from hæmorrhoids), was seized with a slight gastric affection accompanied with giddiness and singing in the ears, and entered the hospital. Some years previously he had often suffered from bleeding from the nose; but of late he had had no kind of hæmorrhage. On further investigation, it was found, that his urine was of a blood-red colour, that he suffered from dysuria, and from an involuntary and con-

tinued desire to pass water, so as to be forced to urinate every quarter-of-an-hour. The last portion of urine passed invariably contained a large quantity of blood. On examination, the orifice of the urethra was found natural, no pain was felt on pressure over the back part of the urethra, nor was anything abnormal found about the prostate or bladder on examination per anum. The bloody-coloured urine deposited, after standing for some time, a scanty darkish-red sediment, which was readily dispersed by shaking, and consisted solely of blood-corpuscles without any admixture of pus. The urine when filtered appeared quite free from blood, and of a bright yellow colour; a dark red precipitate of blood-corpuscles remaining on the filter. The urine consequently contained only blood-corpuscles, and no hæmatine in solution. The blood-corpuscles undoubtedly came from the bladder, and their presence probably resulted from congestion of its mucous membrane, and consequent rupture of blood-vessels.

The treatment consisted in the administration of linseed-tea, with bitter-almond-water; and under it the patient improved in health. The dysuria ceased in the course of a few days, and the blood gradually disappeared from the urine.

13. The following case is of interest, from its close resemblance to a case of hæmaturia; and from the fact, that the absence of this affection was first demonstrated by the microscope.

An old gentleman, of 72, had had for five years an affection of the bladder, which showed itself as follows: He had always been healthy, and was, for his age, very robust. From time to time, after excretion, or after much walking, he passed a small quantity of blood with his urine, and suffered some little pain about the region of the bladder. The simultaneous passing of gravel with his urine, led to the supposition of the presence of a calculus in his bladder; and he had consequently consulted several doctors, and had been many times examined. No stone, however, was found. His affection was therefore regarded as an hæmorrhoidal state of the bladder, and the patient had, in consequence, resorted to the Kissingen and Karlsbad waters, but without deriving any essential benefit from them. He had never passed blood with his motions; nor were hæmorrhoids or any enlargement of the prostate discovered. His general condition was good. There was no rigidity of his arteries.

His urine was very acid, and deposited large crystalline masses of uric acid. There was also observed in it an abundant dirty-red cinnamon-coloured sediment, which was quickly deposited, and contained large flocculi. Before this sediment was deposited, the urine presented the exact appearance as when blood is present in it; and in fact, the patient himself and his many doctors had always hitherto considered that the sediment was caused by blood. Under the microscope, however, numerous cellular forms were found, which, on the first appearance, seemed to be blood-corpuscles, but on closer investigation, were found to be essentially different. They were round, of a red colour, like that of the blood-corpuscles, but somewhat larger, $\frac{1}{300}$ to $\frac{1}{200}''$ diameter; contained a distinct nucleated corpuscle, and were unaffected by acetic acid (see *Plate III. Fig.* 6, D *a a*). With these were found others, some greater and some smaller, irregular and partly caudate cells, for the most part containing nuclei (*Fig.* 6, D *b b b*) partly single, and partly aggregrated (forming thready flocculi visible to the naked eye), and without any trace of a fibrinous basis-membrane. The sediment of the urine also contained normal pus-corpuscles, which, after treatment with acetic acid, exhibited their usual nuclei.

From the presence of these cells, the existence of fungoid excrescences (epithelioma) of the bladder was diagnosed, with tendency to acid urine and separation of uric acid. The treatment ordered was: the regular use of Fachinger water, and linseed-tea, with acetate of potash, and laurel-water. Under this treatment the condition of the patient was much improved. For several months the urine was not coloured with blood; and instead of the epithelioma cells contained merely a few pus-corpuscles, and some thready coagula of mucus. The patient now suffered merely from occasional pains in the glans penis; and straining occurred only during the evacuation of the last drops of urine.

I trust that the above examples will satisfy the reader that the investigation of the state of the metamorphic processes in the sick is of service to the physician; and that the investigation itself is not so exceedingly difficult, as some persons have imagined. But I would, at the same time, earnestly entreat those who may pursue further the path of investigation here pointed out, to confine themselves to the possible, and not endeavour, by the aid of bold hypotheses or ill-founded surmises, to assume conclusions, which our knowledge does not yet enable us to compass. Such proceeding is injurious to the interests of the sick, who trust themselves to our care; and cannot fail to lower, both in the eyes of the profession, as well as of the public, the value of this excellent and philosophic method of investigation of disease, viz., the consideration of the chemistry of the metamorphic processes in diseases.

APPENDIX.

SECTION CXXVI.

URINARY CALCULI AND OTHER URINARY CONCRETIONS.

By urinary concretions, we understand deposits from the urine, which have taken place in the urinary passages, within the kidneys, ureters, bladder, or urethra. Sometimes these concretions are small, like sand, and pass away readily with the urine; in such case, they are usually very numerous, and as a rule, occur in a crystalline form, (sand, gravel). Sometimes again, they are much larger, from the size of a pea up to that of an apple. When of a size too large to admit of their being evacuated with the urine, they are retained in the calyces or pelves of the kidney or in the bladder, and by their mechanical action excite irritation, pain, hæmorrhage, and inflammation of these parts, &c. They may also become fixed in the ureters and urethra. (Calculi.)

Most of these urinary concretions are formed from sediments of the urine, which have been deposited within the urinary passages, and instead of being evacuated, have, through some cause or other, been retained there and gradually formed into large masses; or, again, the calculi may be formed of sediments which have collected round a foreign body, which has found its way into the urinary passages. In the same way urinary concretions may enlarge gradually, and more or less rapidly, fresh layers of sedimentary matters being continually deposited upon them.

No distinct line of demarcation can be made between urinary gravel and the sediments from which they are formed, for one may pass into the other; and the same thing is true of sand and small calculi. Hence there is no practical advantage gained by attempting any arbitrary division of them into separate forms.

A knowledge of urinary concretions is of great importance to the medical man, on account of the inconvenience, and the danger which their presence occasions in the body. It is the business of special pathology and diagnosis to point out to us their nature and treatment. A knowledge, however, of the chemical composition of urinary concretions is of practical use to the physician. Thereby alone can he learn how, by proper medicinal appliances, to prevent the further formation of the sand, which mechanically irritates the urinary passages, or the still more dangerous formation of a calculus, or the further increase of a calculus which has been already formed. It is evident, moreover, that an exact knowledge of the chemical composition of a urinary calculus must form the basis of any attempts to dissolve it within the bladder. The chemical investigation, also, of calculi which have been removed by lithotomy or lithotrity, is often of practical utility, inasmuch as it indicates the proper treatment for the prevention of the recurrence of like urinary concretions in the persons operated upon.

The chemical constituents of urinary calculi are essentially the same as those which have been already considered under the head of urinary sediments, viz:—

Uric acid and urates.
Xanthine.
Cystine.
Oxalate of lime.
Carbonate of lime.
Phosphate of lime.
Ammonio-phosphate of magnesia.
Proteine-compounds (fibrine, mucus).
Urostealith.

These being mixed with minute quantities of other matters—silica, alumina, &c.

Many urinary concretions consist solely of some one of these constituents. Others, again, are composed of several of them; the different constituents in some cases forming separate layers of the concretion.

As the properties and tests of most of these substances have been already described, it is only necessary here to point out the general processes required for the analysis of such concretions, referring for further particulars to their special history.

If we have to deal with sandy deposit, it is advisable, in the first

, to examine it microscopically, as from the form of the crystals
hemical nature of the matter may be often ascertained. For
ical investigation we must isolate the particles of it as far as
ble from all impurities, such as blood and pus, and then wash
with distilled water. If the particles are large, they must be
ced to a fine powder.

dealing with calculi, it must be remembered that they are fre-
tly formed of layers differing in chemical composition. The
s must therefore be cut, or better still, broken in pieces, and
all quantity of powder taken from every layer which pre-
a different appearance, and subjected to analysis. In this case,
it is well to wash the powder with distilled water before com-
ing operations, in order to separate any accidental constituents
e urine which may have become infiltrated into it.

he best method of proceeding, especially for those who are not
ised in these analyses, is, in the first place, to heat a little of the
lered calculus to redness on platinum foil over a spirit-lamp. If
owder be wholly consumed, or leave only a very inconsiderable
unt of residue, it may consist of—

Uric acid or urate of ammonia,
Xanthine (Xanthic oxide),
Cystine,
Proteine-bodies,
Ureostealith.

ext, in order to ascertain which of these substances the con-
on is formed of, we must proceed as follows:—

e first test it for uric acid. If, on treating the powder with
c acid and ammonia, after the manner described at p. 30, 6, and
, *a*., we obtain a distinct murexide-reaction, the concretion con-
of uric acid or of urate of ammonia. These two substances are
nguished by the fact, that uric acid is only very slightly
ble in boiling water, whilst urate of ammonia is much more
ly dissolved, and in larger quantities. As the solution cools it is
precipitated, and, on the addition of a solution of potash, gives
mmonia (Section XXXVII.).

ric acid calculi are, comparatively speaking, of frequent occur-
, and sometimes attain a considerable size. They are rarely
e, being generally of a yellowish, reddish, or reddish-brown
r; they have usually a smooth surface, and are tolerably hard.
rate of ammonia calculi are rarely met with; they are usually

small, of a lightish or loamy colour, and of a more earthy consistence than uric acid calculi.

If the urinary concretion is combustible, and offers no murexide-reaction, it may consist of one of the following bodies:—

Xanthine (Xanthic oxide).—This substance dissolves in nitric acid without evolution of gas; the solution on evaporation leaving a bright lemon-coloured residue, which is not reddened by ammonia, but dissolves readily in caustic potash with a deep reddish-yellow colour. The newly-discovered substance, guanine, has a similar reaction; it is, therefore, necessary to be cautious in deciding that a urinary concretion consists of xanthine. Guanine, however, has never yet been found in urinary concretions.

Calculi consisting of xanthine are extremely rare; only a few specimens, indeed, have been hitherto met with. They have a light-brown (whitish- or cinnamon-brown) colour, are of tolerably firm consistence, take a polish like wax when rubbed, and usually consist of concentric amorphous layers, which are readily separated.

Cystine calculi are also rarely met with. They are of a dull-yellow colour, have a smooth surface, and present on fracture a glistening crystalline appearance. They are softish, may be readily scraped, and when powdered impart a soapy feeling to the fingers.

The following are the chemical characters of cystine:—It is soluble in caustic ammonia, and on slow evaporation of the solution crystallises in very characteristic forms—regular six-sided tables. It is also soluble in mineral acids; and on slow evaporation of an hydrochloric-acid solution crystallises in groups of divergent radiating needles. Cystine contains a considerable quantity of sulphur. Consequently, if a calculus, containing cystine, be dissolved in a solution of potash, and after the addition of a little acetate of lead solution the solution be boiled, a black precipitate of sulphuret of lead is thrown down, and gives the mixture an inky appearance. (See Section XL.)

Calculi formed of *proteine-substances* (of fibrine or blood-coagula) are also very rare. They present no appearance of crystallisation, give off when burnt an odour of burnt horn, are insoluble in water, ether, and alcohol, but are soluble in a solution of potash, from which they are thrown down by acids; in acetic acid they swell up, and are soluble in boiling nitric acid.

Calculi of *urostealith* are equally rare, and have only been noticed by Heller. In their fresh state they are soft and elastic, like caoutchouc to the touch. They shrink up when dried, assume a light-brown or blackish colour, become brittle, and hard, but soften again, when warmed. When heated they fuse, intumesce and give off a very powerful odour, somewhat like that of mixed shellac and benzoine. They soften without dissolving in boiling water. They readily dissolve in ether; and the amorphous urostealith, which remains on evaporation of the ethereal solution, assumes a violet colour when further heated. They also readily dissolve in caustic potash when warmed, and become saponified. They dissolve in nitric acid, with a slight evolution of gas, and without change of colour, the residue, on the addition of alkalies, becoming of a dark-yellow colour.

II. If the concretion is incombustible, or leaves much residue after exposure to red-heat, it may consist of—

Urates, with a fixed base (soda, magnesia, lime),
Oxalate of lime,
Carbonate of lime,
Phosphate of lime, or of
Ammonio-phosphate of magnesia.

Urate of soda, urate of lime, and urate of magnesia, are rarely met with as the sole constituents of a urinary calculus; they are, however, occasionally found in varying quantities in calculi, which consist chiefly of other substances, in uric acid and urate of ammonia, calculi, for instance.

In order to ascertain whether any of these bases are contained in a uric acid calculus, we boil the pulverised calculus in distilled water, and filter the solution while hot. The urates, being more soluble in hot water than uric acid, will, if present, be contained in the filtrate. The filtrate is then evaporated, and the residue heated to redness. The fixed bases will remain in the incinerated mass, which, if it renders moistened turmeric-paper brown, we may conclude contains soda or potash. The soda is distinguished by the yellow tinge which it imparts to the flame of the blow-pipe. If too great heat has not been applied to the residue, magnesia and lime, if present in it, will remain in the forms of carbonates; these are insoluble in water, but dissolve readily in dilute acids. From such solutions the earths are precipitated as ammonio-phosphate of magnesia, and as phosphate of lime, on the addition of phosphate of soda and ammonia.

Oxalate of lime, when strongly heated, blackens in consequence of the combustion of its organic matter; but by prolonged exposure to heat it becomes white, without undergoing fusion. By still further exposure to heat it is converted into caustic lime, which renders moistened turmeric-paper brown. By a less degree of heat carbonate of lime is formed, which dissolves in hydrochloric acid with effervescence. No precipitate is formed when this solution is neutralised with ammonia, but when oxalic acid is also added, oxalate of lime is thrown down, whose characteristic form of crystals may be seen under the microscope (see Section XXXVIII. B). Oxalate of lime is insoluble in boiling water, and caustic potash solution; it is soluble in hydrochloric acid without effervescence.

Oxalate of lime calculi are often met with, especially in children. They are either small, of a pale colour and smooth, of the size of hempseed—or they are larger, have a rough, warty, nodular surface, and are generally of a dark, brownish, or even blackish colour—*mulberry calculi*. These latter calculi usually cause, by their roughness, much irritation in the urinary passages, producing great distress, inflammation, and hæmorrhage.

Calculi composed chiefly or entirely of *carbonate of lime* are rare; when met with, they have generally been found in large numbers in the same individual. They have a whitish-grey—rarely a darker, yellowish, or brownish—colour, and present an earthy chalk-like appearance. Carbonate of lime is most frequently met with in small quantity as a component of other calculi, mixed, for instance, with oxalate of lime or earthy phosphates.

Carbonate of lime concretions become black when burnt, in consequence of the presence of much organic matter (mucus) in them, but are readily rendered white by further heating. They are not fusible. The residue, when exposed to a strong heat, exhibits exactly the same qualities as that of oxalate of lime calculus. It either remains in the state of carbonate of lime, or is converted into caustic lime.

These calculi are easily recognised by their characteristic property of dissolving in hydrochloric acid with effervescence.

Ammonio-phosphate of magnesia and *basic phosphate of lime* usually occur together as constituents of urinary calculi. Calculi of this kind indicate, that the urine has been for a length of time ammoniacal while in the bladder, in consequence of the decomposition of its urea. These calculi often become of considerable size, and have generally a whitish colour. When the phosphate of magnesia and ammonia predominates in them they are softish, porous, and chalky; but when the phosphate of lime is in excess they become thicker and harder.

The following are their chemical characters:—

They are incombustible, but when exposed to a strong heat, fuse into a white enamel-like mass, and have, in consequence, been called fusible calculi. They never become alkaline, however strongly heated, and may thus be distinguished from calculi of oxalate of lime and carbonate of lime. They are soluble in hydrochloric acid without effervescence, both before and after exposure to strong heat; and the solution of the fused pulverised mass is precipitated with ammonia.

To separate these two constituents—phosphate of lime and phosphate of magnesia and ammonia—from each other, we proceed as follows: The calcined powder is dissolved in dilute hydrochloric acid, and the solution filtered. Ammonia is then carefully added to the solution, so as to leave it very slightly acid, or the solution may be completely neutralised with ammonia, and the cloudiness which appears then removed by the addition of a few drops of acetic acid. If oxalate of ammonia now be added, the lime alone will be thrown down as an oxalate, the phosphate of magnesia and ammonia remaining in solution. After separating the precipitate by filtration, the phosphate of magnesia and ammonia may be obtained by supersaturation with ammonia.

Neutral phosphate of lime calculi have been met with in some very rare instances. In their physical and chemical characters they resemble calculi of the earthy phosphates; but as they contain no magnesia, their solution in hydrochloric acid, after precipitation of the lime with oxalate of ammonia, yields no further precipitate when treated with an excess of caustic ammonia.

Urinary calculi, however, sometimes have a more complicated composition, being formed of several different constituents. Thus, for instance, there are calculi which consist of uric acid, and of urates, and of earthy phosphates; and others again which are formed of a mixture of oxalate of lime and of earthy phosphates. Calculi have, indeed, been met with, which were composed of uric acid, urate of ammonia, oxalate of lime, phosphate of lime, carbonate of lime, and ammonio-phosphate of magnesia, that is to say, of six different constituents. These various constituents of calculi are sometimes intimately mingled together, and sometimes deposited in separate layers, which have manifestly been formed at different periods. This is explained by the fact, that in the same patient different urinary sediments appear in the urine at different times, and are deposited upon a pre-existing calculus, and increase its size. Alternate layers of uric acid and urates, for example, are formed, when, in a case of uric acid diathesis, the urine is at one time very acid, so that the urates are decomposed, and the uric acid separated; and at another less acid or neutral, so that the undecomposed urates are precipitated on the calculus. If the uric acid diathesis alternate with the oxalic acid diathesis, the calculus will be formed of alternating layers of uric acid and oxalate of lime. The calculi frequently met with, composed of alternate layers of uric acid, or oxalate of lime and phosphatic earths, are formed through the periodical re-occurrence of the uric acid or oxalic acid diathesis, the urine being rendered ammoniacal in the intervals through decomposition of the urea. The decomposition in such case results from the presence of the large quantity of mucus, which is produced by the irritation of the calculus, or from temporary obstruction to the flow of the urine. Alternate layers of uric acid and phosphate of lime in the same calculus are sometimes artificially produced by drugs, as when alkalies are administered to counteract the uric acid diathesis. The alkalies make the urine alkaline, and consequently occasion a deposition of the sediment of phosphate of lime upon the calculus.

Calculi usually have a nucleus, this is in some cases formed of a foreign body, around which the urinary sediments collect and become incrusted. All foreign bodies which find their way into the urinary passages, or have been formed there, such as blood-coagula, masses of mucus, and fibrine, may become the nuclei of urinary calculi. Sandy particles retained in the bladder, may also form the nuclei of calculi. In the latter case the nucleus has sometimes a different composition from the rest of the calculus, on account of the urinary sediment having undergone a change during its formation. Sometimes the calculus has a cavity in its centre instead of a nucleus; and in such case the nucleus which originally consisted of mucus has dried and shrivelled up. In some rare cases, the nucleus is found to rattle within the calculus; in such case it is also formed of dried-up mucus. Occasionally, the calculus consists of sandy particles, or of several small calculi, united together by a menstruum, which may, or not, have the same chemical composition as the calculi themselves.

These different facts must all be taken into consideration, in investigating the chemical constitution of urinary calculi, and in drawing conclusions concerning the probable conditions which attend their formation.

Spurious or false urinary calculi are also met with, and their diagnosis is of importance in cases where, for instance, an hypochondriacal patient has got the idea into his head, that he is suffering from calculus or gravel. Thus it has happened that sand or little pieces of stone, which have accidentally found their way into the chamber-utensil, have been taken for urinary concretions. These usually consist of silicates, and may be in most cases readily distinguished from urinary calculi, by their external appearance and physical properties (extreme hardness), of course also by their chemical characters. On chemically examining these false concretions the characteristic properties of the substances which form urinary calculi, &c., will not be met with, and, moreover, analysis (fusion with carbonate of potash, soda, &c., as described in Section XVIII.) will generally show the presence of a large quantity of silica, which is not met with in true urinary concretions, or only in very minute quantities.

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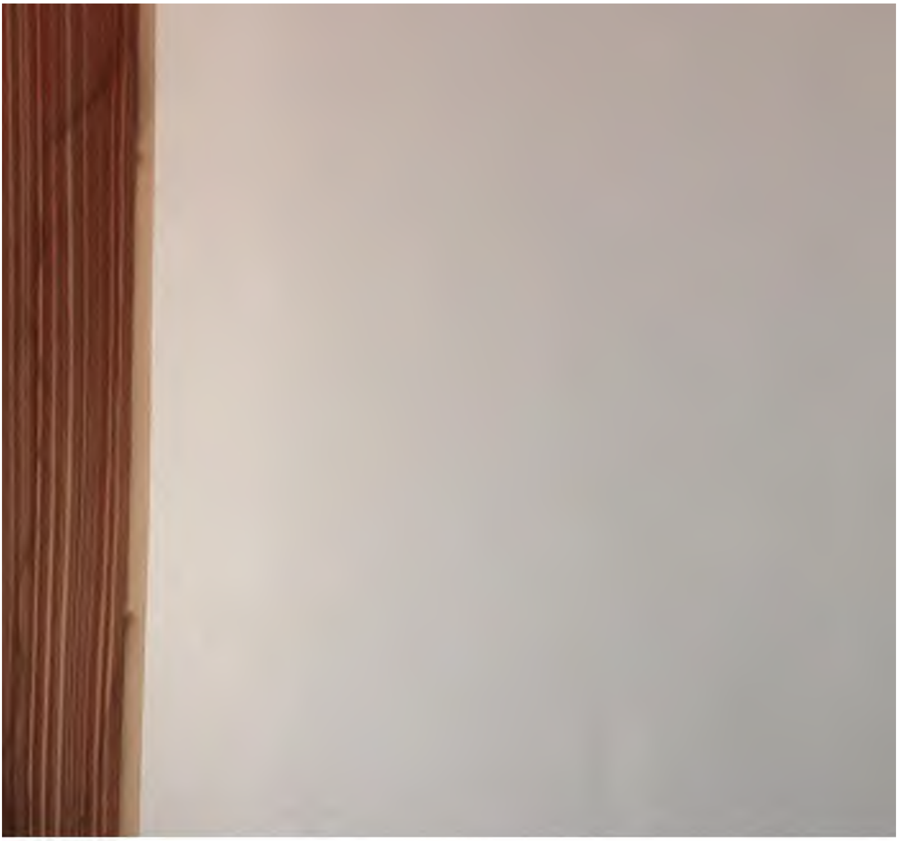

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